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CARL MURCHISON

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TABLE OF CONTENTS

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Carl Murchison

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REVERSALS IN READING AND WRITING MADE BY PUPILS IN THE KINDERGARTEN AND PRIMARY GRADES*[1]

Hunter College, and Teachers College of Columbia University

FRANK T. WILSON AND CECILE WHITE FLEMMING

A. INTRODUCTION

During the school year 1933-1934 a variety of tests was given to 25 children in Grade I of the Horace Mann School, Teachers College. These included tests of "reading readiness", many of the Gates *Reading Diagnosis Tests*, some reading achievement tests; mental ability tests, such as the Stanford Revision of the Binet-Simon tests and various performance tests; certain psychological tests as of perception and perseveration, and several measures of psycho-physical and personality traits and of home background. A total of 106 measures was obtained. The purpose of the study was to examine any possible relationships that might exist between measurable traits and abilities and early progress in the mechanics of reading.

The children of the group came from well-to-do homes. A large percentage of the parents were professional people. The following averages for these pupils were found.

Chronological age, January 1, 1934	6.31
Mental age, January 1, 1934	7.61
Intelligence quotient	120.6

During the next two school years the investigation was extended to the four- and five-year-old kindergarten groups, four other first grades, four second grades, and two third grades of the Horace

*Received in the Editorial Office on November 17, 1937.

[1]This report presents a minor phase of a study of Reading Readiness and Reading Progress in the Primary Grades of the Horace Mann School, Teachers College, New York, 1933-37. The study was carried on under the supervision of Doctor Cecile White Flemming, Director of Pupil Individual Development and Guidance, and of Doctor Rollo T. Reynolds, Principal. Prepared with the assistance of the U. S. Works Progress Administration, New York City, Project Number 165-97-6172, Sub-Project 4.

Mann School. In all, fourteen groups of children were involved, totaling more than four hundred individuals.[2]

In the kindergartens and first grades nearly every test and measurement was given or made individually, under carefully controlled conditions, and by reliable persons accustomed to administering tests to young children. In Grades 2 and 3 many individual tests and some group tests were used. The cooperation of the pupils was almost invariably excellent. It is believed that errors of examination were unusually low.

This report presents first, the results of correlations derived from measures of reversals with 79 other measures and appraisals of children in one first grade, second, analyses of the reversals they made, and third, grade variations in reversals from data gathered from the tests given to all the groups.

List 1 describes the tests in which reversals were made by the Grade 1 group which was studied intensively. Some of these tests and a few others, as indicated in tables showing the results, were given to the pupils in the other grades.

[2]The average mental age and intelligence quotient for each of these 14 groups, as measured by the Stanford-Binet Intelligence Examination, are shown below. These measures are recorded as of January 1, or mid-year for each group.

	Average Mental Age	Average Intelligence Quotient
Four-year-old Kindergarten 1935-36, number of pupils 21	5.5 yrs.	130
Five-year-old Kindergarten 1934-35, number 54	6.7	120
Five-year-old Kindergarten 1935-36, number 48	6.6	120
Grade I		
Class Group *G*-1, number 31,—1934-35	7.8	119.7
Class Group *F*, number 28,—1934-35	7.7	120.9
Class Group *G*-2, number 26,—1935-36	7.8	120.9
Class Group *A*, number 25,—1935-36	8.1	132
Grade II		
Class Group *D*-1, number 31,—1934-35	8.8	121.7
Class Group *E*-1, number 25,—1934-35	8.4	116
Class Group *D*-2, number 28,—1935-36	8.9	121
Class Group *F*-2, number 21,—1935-36	8.9	120
Grade III		
Class Group *H*, number 29,—1935-36	10.0	120
Class Group *I*, number 28,—1935-36	9.5	118

LIST 1 TESTS PRODUCING REVERSALS WHICH WERE USED IN THE REPORT

A Tests using visual presentation of material

1 Metropolitan Readiness Tests for Kindergarten and Grade I
 Subtest 1, requiring seeing the similarity and dissimilarity of pairs of symbols;
 Subtest 2, requiring copying of geometrical forms, numbers and letters
 Subtest 5, requiring writing of the digits 4, 7, 2, 5, 9, 6
2. Stone and Grover Classification Test for Beginners in Reading
 Part I, matching a given word with one of five;
 Part II, marking pairs of words as the same or different
3 Gates Diagnosis Reading Tests
 Subtest IX, 1-7, pronouncing phonic combinations;
 Subtest IX, 9, giving letter sounds;
 Subtest IX, 10, naming capital letters;
 Subtest IX, 11, naming small letters;
 Subtest VIII, 2, recognizing words seen.

B. Tests using auditory presentation of material

4 Gates Diagnosis Reading Tests
 Subtest VIII, 3, recognizing words heard;
 Subtest XIII, 3, adapted writing capital and small letters and digits;
 Subtest XIII, 1-2, writing words;
 Subtest X, 1, blending sounds heard

The correlations were obtained by the rank order method To secure rank orders all measures and appraisals were reduced to numerical scores Owing to lack of facilities it was not feasible to make all the computations that were possible A "finder" device was used to select for computation those correlations which seemed to promise significance. It is believed that through the use of this device, although it was not altogether accurate, all the high and fairly high correlations were found No correlations of seemingly unusual size were obtained, however, and few which were inconsistent with other correlations for the same kind of traits and abilities found in the study The opinion of the teacher, of the school psychologist, and of other qualified persons who have studied the figures, is that the results have quite high reliability and validity

Representative *PE*'s of *rho*'s, when *N* equals 25, are given in Table 1

TABLE 1
REPRESENTATIVE *PE*'s OF *Rho's* WHEN $N = 25$

Rho	*PE*	*Rho*	*PE*
.90	.025	.55	.091
.85	.035	.50	.099
.80	.046	.40	.112
.75	.056	.30	.122
.70	.066	.20	.129
.65	.075	.10	.134
.60	.083		

TABLE 2

CORRELATIONS OF REVERSALS WITH 74 OTHER MEASURES AND APPRAISALS

	Reversals V.	Reversals A.
Reversals, visual, reversals, auditory	26	16
*Metropolitan, similarities	45	24
Grip	39	13
**G.D. X, 1, blending sounds heard	35	34
*Metropolitan, sentences	34	11
**G.D. VIII, 3, recognizing words heard	32	32
***Van Wagenen, word learning	31	16
**G.D. XV, 1, memory span, digits	30	10
*Metropolitan, copying	28	12
***Van Wagenen, word discrimination	25	-16
Metropolitan, total	25	16
**G.D., XV, 4, memory span familiar words	25	25
*Metropolitan, vocabulary	24	05
Seguin form board, time	24	20
Mare and Foal, Healy-Fernald, time	24	15
**G.D. XV, 1-4, total memory span	23	28
Mare and Foal, Healy-Fernald, errors	22	05
**G.D. X, 3-4, giving initial and final sounds	22	03
*Metropolitan, drawing man	21	22
**G.D. X, 1-4, total auditory perception	21	10
Maller and Elkin, attention test, perseveration	21	17
Gates Primary Reading Test, Type III, paragraphs	20	09
**G.D. XV, 2, memory span, letters	20	-08
**G.D. IX, 9, giving letter sounds	19	13
**G.D. XI, 1, repeating nonsense syllables	19	06
*Stone, Part II, word matching	17	13
**G.D. XIII, 3, write letters	16	15
**G.D. XV, 3, memory span, nonsense syllables	16	28
Total omissions, nine tests including subtests	16	02
Ship test, Pintner-Patterson	14	-13
Gates Primary Reading Tests, Type I, word recognition, May	14	01
Gates Primary Reading Tests, Type I, word recognition, Nov	13	-07
**G.D. X, 2, recognizing letters heard	13	05
**Hildreth, matching sentences	13	22
Nervousness index, parents' questionnaire	13	
**G.D. IX, 1-7, phonic combinations, and 9, giving letter sounds	12	04
Gates Primary Reading Tests, Type II, directions	11	-06
***Van Wagenen, relations	10	12
Gates Primary Reading Tests, Type I, word recognition, March	09	14
***Van Wagenen, vocabulary	08	18
Total Vocabulary, time	08	19
Mental Age, Stanford-Binet	08	12
Healy Picture Completion Test, II	07	10
Tapping, Whipple-Healy	07	25
Chronological Age	07	-10
Teacher's ranking of pupils in November, prediction	07	02

TABLE 2 (*continued*)

Reversals, visual, reversals, auditory	Reversals V 28	Reversals A 28
Total errors, nine tests including subtests	.07	17
Variation from height-weight norms	.07	
*Metropolitan, numbers	.05	18
**G D IX, 1-7, phonic combinations	05	05
Developmental index, parents' questionnaire	05	
Perception, original test	04	31
†Stone, Total, Parts I and II	03	—03
**G D XIII, 3, adapted, writing time, capital and small letters and digits	03	17
‡Hildreth, matching phrases	03	05
Intelligence Quotient, Stanford-Binet	03	18
Teacher's ranking of pupils in reading, May, ability	03	02
Gates Primary Reading Tests, Type II, directions, May	03	—10
Gates Primary Reading Tests, Type III, paragraphs, May	03	08
†Stone, Part I, word matching	.01	—19
**G D VIII, 2, recognizing word seen	—01	.27
Total vocabulary, Stanford-Binet lists, Action-Agent, Kindergarten list	—01	—36
‡Hildreth, matching words and phrases in sentences	—03	—.08
**G D IX, 10, naming capital letters	—03	09
***Van Wagenen, memory span	—04	08
**G D XIII, 1-2, writing words	—04	.00
‡Hildreth, matching words	—04	.33
‡Hildreth, total	—05	.15
Steadiness, hole apparatus	—10	07
**G D XI, 2, plus supplement, recognizing words as same or different	—11	.09
**G D IX, 11, naming small letters	—13	—01
**G D XI, 2, recognizing words as same or different	—13	—08
Manikin, Pintner-Patterson, time	—15	15
*Metropolitan, information	—26	00

*Hildreth, Griffith, Orleans Metropolitan Readiness Test for Kindergarten and Grade I
**Gates Diagnosis Reading Tests
***Van Wagenen Reading Readiness Test
†Stone and Grover, Classification Test for Beginners in Reading
‡Hildreth, First Grade Reading Analysis Test

Frequency Table of Above *Rho*'s

40 to 49	1	2			
30 to 39	6	4			
20 to 29	16	9			
10 to 19	15	19			
00 to 09	22	16			
00 to —09	8	13	Total	74	71
—10 to —19	5	7			
—20 to —29	1	0	Average	.115	097
—30 to —39	0	1			

B. Findings

1. *Grade I, 1933-1934*

a. Correlations. Table 2 gives the computed correlations of the two types of reversals with the 79 other measures and appraisals used in the study. Several points are of interest in connection with this table. (*a*) The visual reversals gave a correlation of .38 $PE \pm$ .1235, with the auditory reversals. This coefficient is quite low, but is not zero. It indicates a possible but slight relationship between tendencies to make reversals of these two types. Perhaps there was a common or general factor involved in making reversals by the pupils studied, but if so, it was of very limited influence.

(*b*). The correlations of mental age with visual and auditory reversals were .08 and .12, respectively. Those with the intelligence quotient were .03 and .18. These figures indicate practically no relationships.

(*c*). The largest correlations shown in the table were .30 and .43 for grip with visual and auditory reversals, respectively, .35 and .34 for recognition of blended words, .30 and .40 for a memory span test of digits, and .18 and .24 for a similarities test. The large probable errors of these coefficients, indicated by Table 1, make it improbable that the correlations found were of much significance.

(*d*). Comparison of the coefficients of the two classifications of reversals throughout the table reveals substantial agreement in nearly all instances, when the large size of the probable errors is kept in mind. This agreement further indicates the general reliability of the data.

(*e*) The averages for the 74 coefficients in the visual group and the 71 in the auditory group, were .115 and .087, respectively. The ranges were from .45 to —.26 and .43 to —.36. Both the averages and the ranges indicate little relationship of reversals to the other traits and appraisals measured.

Tables 3 to 7 present the correlations of reversals with groups of reading, letter ability, mental ability, psycho-physical, and personality measures, respectively. The averages of the coefficients for both visual and auditory reversals for all of these groups of measures were very low, indicating practically no relationships at all.

TABLE 3

CORRELATIONS OF REVERSALS WITH READING MEASURES

	Reversals V	Reversals A
Gates Primary Reading Tests, Type I, word recognition, Nov	13	—07
Gates Primary Reading Tests, Type I, word recognition, March	09	11
Gates Primary Reading Tests, Type II, directions, March	11	—06
Gates Primary Reading Tests, Type III, paragraph reading, March	20	—09
Hildreth First Grade Reading Analysis Test, matching phrases	03	05
Hildreth First Grade Reading Analysis Test, matching words	—04	33
Hildreth First Grade Reading Analysis Test, matching sentences	13	22
Hildreth First Grade Reading Analysis Test, matching words and phrases in sentences	—03	—08
Hildreth First Grade Reading Analysis Test, Total	—05	15
Teacher's ranking of pupils in November, prediction	07	07
Teacher's ranking of pupils in May, ability	03	02
Gates Primary Reading Tests, Type I, word recognition May	14	01
Gates Primary Reading Tests, Type II, directions, May	03	—10
Gates Primary Reading Tests, Type III, paragraph reading, May	03	08
Averages	063	043

TABLE 4

CORRELATIONS OF REVERSALS WITH MEASURES OF LETTER ABILITIES

	Reversals V	Reversals A
Stone and Grover Classification Tests Part I, matching words	01	—19
Stone and Grover Classification Tests Part II, matching words	17	13
Gates Diagnosis, VIII, 2, recognizing words seen	—01	27
Gates Diagnosis, VIII, 3, recognizing words heard	32	32
Gates Diagnosis, IX, 1-7, phonic combinations	05	05
Gates Diagnosis, IX, 9, giving letter sounds	19	13
Gates Diagnosis, IX, 1-7 and 9	12	04
Gates Diagnosis, X, 1, blending sounds heard	25	34
Gates Diagnosis, X, 2, recognizing letters heard	13	05
Gates Diagnosis, X, 3-4, giving initial and final sounds	22	—03
Gates Diagnosis, X, total	21	10
Gates Diagnosis, XIII, 1-2, writing words	—04	00
Gates Diagnosis, XIII, 3, writing letters	16	15
Gates Diagnosis, IX, 10, naming capital letters	—03	09
Gates Diagnosis, IX, 11, naming small letters	—13	—01
Gates Diagnosis, XI, 2, recognizing words as same or different	—13	—08
Gates Diagnosis, XI, 2, plus supplementary list	—11	09
Gates Diagnosis, XV, 2, memory span, letters	20	—08
Averages	088	076

TABLE 5

CORRELATIONS OF REVERSALS WITH MENTAL MEASURES

	Reversals V	Reversals A
Van Wagenen Reading Readiness Test, information	21	05
Van Wagenen Reading Readiness Test, relations	10	12
Van Wagenen Reading Readiness Test, vocabulary	08	18
Van Wagenen Reading Readiness Test, memory span	04	18
Metropolitan Readiness Tests, vocabulary	23	05
Metropolitan Readiness Tests, sentences	43	11
Metropolitan Readiness Tests, numbers	05	19
Metropolitan Readiness Tests, information	-26	[illegible]
Metropolitan Readiness Tests, drawing man	21	22
Gates Diagnosis, XI, 1, repeating nonsense syllables	19	[illegible]
Vocabulary, Stanford-Binet lists, Action-Agent, kindergarten list	-01	-36
Seguin Form Board, time	23	[illegible]
Mare and Foal, errors	22	.05
Mare and Foal, time	21	15
Manikin, Pintner-Patterson	-15	15
Ship Test, Pintner-Patterson	14	-13
Healy Picture Completion Test, II	07	10
Mental Age, Stanford-Binet	08	12
Intelligence Quotient, Stanford-Binet	03	18
Gates Diagnosis, XV, 1-4, memory span, total	23	28
Averages	11	07

TABLE 6

CORRELATIONS OF REVERSALS WITH PSYCHO-PHYSICAL MEASURES

	Reversals V	Reversals A
Total Writing Time	03	17
Total Vocabulary Time	08	-19
Perception, (Original Test)	.04	31
Steadiness, hole apparatus	—10	07
Tapping, Whipple-Healy	07	25
Perseveration, Maller and Elkin, Attention Test	—21	17
Chronological Age	07	—10
Grip, dynamometer	39	43
Variation from height-weight-age norms	07	
Developmental Index, parents' questionnaire	05	
Averages	05	139

TABLE 7

CORRELATIONS OF REVERSALS WITH PERSONALITY MEASURES

	Reversals V	Reversals A
Total errors	.07	02
Nervousness Index, parents' questionnaire	13	
Averages	.10	02

TABLE 8

Analysis of Reversals in Tests, Fall Semester, Grade I (N = 25)

	[illegible]	[illegible] 2	No. [illegible]	[illegible]
Section I, Metropolitan Readiness Test				
Test 1, Similarities	[illegible]	same	[illegible]	[illegible]
Marking pairs of [illegible]	2 [illegible] 21	same		
same or different	[illegible]	same	19	[illegible]
Total	3 [illegible] 3	5	2[illegible]	[illegible]
Test 2, Copying	[illegible] form	reverse	2	[illegible]
	[illegible] form	reverse	1	4
	[illegible] form	reverse	2	[illegible]
	[illegible]	reverse	9	36
	symbols	reverse	4	16
	63	36, 6E	2	8
	CA	C-reversed A	1	4
	SdL	l-reversed SD, LGE, SDL, E	4	16
Total	8	12	25	13
Test 5, Writing Digits	4	reverse	4	16
	7	reverse	7	28
	2	reverse	8	32
	5	reverse	2	8
	9	reverse	10	40
	6	reverse	7	28
Total	6	6	38	25

TABLE 8 (*continued*)

	Stimuli (1)	Reversal responses made (2)	No of reversals made (3)	% reversals No made divided by No reversals possible (4)
Section 2. Stone and Grover Classification Test for Beginners in Reading Part I, Matching a given word with one of five	top	pot	1	4
	saw	was	4	16
	no	on	4	16
	from	farm, move	4	16
	frog	gort, forg rogt	10	40
	farm	fram, frame mrof	2	8
	saw	was	4	16
	from	form	1	4
	on	no	11	44
Total	9	[illegible]	[illegible]	22
Section 3. Gates Reading Diagnosis Tests VIII, 2 [illegible] six words [illegible] exposed 3 seconds and then [illegible]	1 [illegible]	[illegible]	2	[illegible]
	2 [illegible]	[illegible]	2	[illegible]
	3 [illegible]	[illegible]	[illegible]	[illegible]
	4 saw	[illegible] 2 [illegible] 1	3	[illegible]
	5 [illegible]	[illegible] 2 [illegible]	2	[illegible]
	6 [illegible]	[illegible] 2 [illegible]	3	[illegible]
	7 [illegible]	[illegible]	1	4
	8 [illegible]	[illegible]	[illegible]	[illegible]
	9 [illegible]	[illegible] 1 [illegible] 2	3	[illegible]
	[illegible]		3	[illegible]
	[illegible]	[illegible]		
		[illegible]	[illegible]	
Total	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 8 (*continued*)

	Stimuli (1)	Reversal responses made (2)	No of reversals made (3)	% reversals No made divided by No reversals possible (4)
Section 4 Gates Reading Diagnosis Tests VIII, 3, Indicating among six words shown a word that had been heard	1 on	no	4	16
	2 ma	am	2	8
	3 dew	wed 3, ewd 2	5	20
	4 pan	nap 3, anp 3	6	24
	5 saw	was 4, aws 3	7	28
	6 lap	pal 3, alp 1	4	16
	7 not	ton 2, otn 2	4	16
	8 dab	bad 2, abd 2	4	16
	9 won	now 5, own 8	13	52
	10 ten	net 0, ent 2	2	8
	20 answer	werans 3		
		rewsna 2	5	20
		20	56	20
Section 5 Gates Diagnosis Tests, IX, 9, Giving letter sounds from lower case letter print	b	d	3	12
	d		0	0
	p		0	0
	q		0	0
Total	4	1	3	4
Section 6 Gates Diagnosis Tests, IX, 11, Naming letters from lower case print	b	d	2	8
	d	b	1	4
	p	q	3	12
	q	p	8	32
Total	4	4	14	13

TABLE 8 (*continued*)

	Stimuli (1)	Reversal responses made (2)	No of reversals made (3)	% reversals made / No reversals possible (4)
Section 7 Gates Diagnosis Tests, XI, 1, Blending sounds heard	by		0	0
	an	an	1	4
	up	pee	1	4
	men		0	0
	fly	fy	1	4
	end		0	0
Total	6	3	3	2
Section 8 Gates Diagnosis Tests, XIII, 1, Writing words dictated	at		0	0
	no		0	0
	boy	yo 1, oy 2	5	12
	was	saw	1	4
	cat	at	1	4
Total	5	4	5	4
Section 9 Gates Diagnosis Tests, XIII 2, Writing words spelled	me	m	1	4
	on		0	0
	dog	dgo, bug, god	5	12
	now		0	[illegible]
	toy		0	[illegible]
Total	5	4	[illegible]	[illegible]

TABLE 8 (*continued*)

	Stimuli (1)	Reversal responses made (2)	No of reversals made (3)	% reversals made No reversals possible (4)
Section 10 Gates Diagnosis Tests, XIII, 3-A, Adapted Writing capital letters by dictation	B	reverse	2	8
	C	reverse	2	8
	D	reverse	1	4
	J	reverse	7	28
	Y	reverse	1	4
	P	reverse	1	4
	R	reverse	1	4
	S	reverse	1	4
	Z	reverse	2	8
Total	9	9	18	8
Section 11. Gates Diagnosis Tests, XIII, 3-B, Adapted Writing small letters by dictation	b	reverse	4	16
	c	reverse	1	4
	d	reverse	8	32
	j	reverse	6	24
	k	reverse	1	4
Total	5	5	20	16
Section 12 Gates Diagnosis Tests, XIII, 3-C, Adapted Writing digits by dictation	2	reverse	6	24
	3	reverse	8	32
	4	reverse	4	16
	7	reverse	9	36
	9	reverse	5	20
	5	—	0	0
	6	—	0	0
	10	reverse	1	4
Total	8	6	33	16

b. Analysis of reversals

Table 8 shows by test items the reversals which the pupils made. At the left are shown the test and subtest titles. In Column 1 are given the test stimuli which provided possible reversal responses; in Column 2 the reversal responses made by the children are given; in Column 3 the number of reversals made is shown; and in Column 4 are given the percentages that the reversals made were of the total number of reversals that were possible. Presumably 25 reversals on each item might have been made by the group of 25 children. In instances, such as in the Gates *Diagnostic Reading Tests*, Table VIII, 2 and 3, either full or partial reversals were possible. All such errors were counted as reversals, but each child could make but one response on each item. In other items words or groups of letters or numbers were written by the children. Each word, letter or number so reversed was counted as a separate reversal.

Table 9 summarizes Table 8 by subtests. The nature of the test material is given in Column 1. The total number of reversals made is shown in Column 2. In Column 3 are given the possible number of reversals that might have been made. In Column 4 are shown the percentages that the reversals made were of the possible number that could have been made, placed in Sub-Columns *V* and *A* according to whether the stimuli of the tests were visual or auditory. The tests are arranged in the table in the order of the size of the percentages in Column 4.

A total of 327 reversals was made by the pupils out of a possible 2,350, or 13.9 per cent. There is no evidence that either visual or auditory stimuli favored reversal tendency. Under either condition many reversals occurred. The totals were 150 in response to visual stimuli, 177 in response to auditory stimuli.

The source for the highest percentage of reversals was the Metropolitan similarities test, Test 1, shown in Table 8, Section 1. In this test the children were to indicate similarity between two items placed side by side in columns. For example, *DC* and *CD* made one pair. Nine children marked them as the same. None confused 291 and 216, but 19 indicated that *on* and *no* were the same. This last named item gave the greatest number of reversals of any item in all the tests. The remainder of the items in this Metropolitan subtest were drawings and figures. No reversal errors were made with them.

Test and nature of material	(1)	Total no reversals made (2)	Total possible reversals (3)	% reversals number of reversals made divided by no of possible reversals V	(4)	A
Metropolitan Readiness Test for Kindergarten and Gr 1 similarities	words, letters	28	75	39		
	digits	38	150			25
Stone and Grover Classification Test	words	50	225	22		
Gates Diagnosis						
VIII, 3	words	56	275			20
XIII, 3-B	small letters	20	125			16
XIII, 3-C	digits	33	200			16
IX, 11	small letters	14	100	13		
VIII, 2	words, letters	30	275	13		
Metropolitan Readiness Test copying	forms, words letters, digits	25	200	13		
Gates Diagnosis Tests						
XIII, 3-A	capital letters	18	225			8
XIII, 1	letters	5	125			4
IX, 9	letters	3	100	4		
XIII, 2	letters	4	125			2
X, 1	letters	3	150			2
Total		327	2350		13 9	
		v 150				
		a 177				

The next highest percentage of reversals, 25 per cent, was made in the Metropolitan digits test, Test 5 (Table 8, Section 1). In this test the digits that gave the most reversals were, in order, *9*, *2*, *7* and *6* as shown in Table 8. The digit *3* was not used, unfortunately, in this test. The Gates Diagnosis sub-test XIII, 3C, adapted (Table 8, Section 12) was also a test of writing digits by auditory stimulus. There was this difference, however. In the Metropolitan test the children were told to write numbers that were answers to problems, while in the adapted Gates test the numbers were dictated in a random order. The percentage of reversals in the Gates test was 16, as compared with 25 for the Metropolitan. The Gates test was given about three months later than the Metropolitan. In the Gates test the digits, omitting the number *3*, producing the greatest number of reversals were *7*, *2* and *9*, while *6*, *5* and *4* gave the fewest. These results indicate about the same relative reversal tendencies as did the Metropolitan test, except for the digit *6*.

The third most productive source of reversals was the Stone and Grover Classification test (Table 8, Section 2). In this test words were matched by the children in Part I by marking the one word among five that was the same as a nearby word under a picture. In Part II the children indicated that two words side by side were the same or different. Table 8 shows that *on* and *no* were marked as being the same in this test by 11 children. This compares with 19 errors on this word in the Metropolitan test just noted above, shown in Table 8, Section 1. Confusion of *no* and *on* was possible in five other tests. In the Gates sub-test VIII, 3 (Table 8, Section 4), four children pointed to *no* in response to the spoken word *on*. In the Stone test, Part I (Table 8, Section 2), four children marked *on* as the same as *no*. They were different children in the two tests, however. In the Gates sub-test VIII, 2 (Table 8, Section 3) two children pointed to *on* after looking at *no*. These were still other children than those in the Stone and Gates test just mentioned. In the Gates sub-tests XIII, 1 and 2 (Table 8, Sections 8 and 9) no children wrote *on* for the dictated or spelled word *no*. These results indicate no general tendency, but rather specific habits subject to influences of particular situations. There may have been a tendency to make a reversal more frequently when the stimulus word was *on* than when it was *no*, but this seems very doubtful.

When the Stone test is examined further it is seen that the next highest source of reversals was with the word *frog* (Table 8, Section 2). Ten children indicated 3 reversal forms as the same as *frog*. The construction of the test may explain this large number of reversals, in that more reversal forms were presented for this word, than for any other word except *farm*. In the instances of both *frog* and *farm* three reversal forms were presented. The number presented, however, gave no certainty of reversal responses as reference to Table 8, Section 2, indicates. Considerable variation in the number of reversals occurred regardless of the number of reversal forms presented.

The word *saw* was given twice in the Stone test. In Part I it brought the response *was* by four children, and in Part II by two of the same children and by two others. Two pupils who made the error in Part I did not do so in Part II. The words *saw* and *was* were presented in three other sub-tests. In the Gates sub-test VIII, 2 (Table 8, Section 3), three children indicated *was* for the stimulus word *saw*. In the Gates sub-test VIII, 3 (Table 8, Section 4), four children made the same error, and three others indicated *aws* as the spoken word *saw*. In the Gates sub-test XIII, 1 (Table 8, Section 8), one child wrote *saw* for the stimulus word *was*.

Table 9 shows that the next highest source of reversals was the Gates sub-test VIII, 3, which produced 20 per cent reversals. This was due to a considerable degree to the word *won*, which produced 13 of the 56 reversals in that test. This word was not defined and was quite evidently confused with *one*, as 8 children pointed to the word *own* as the correct word. Five pupils, however, indicated *now*, the full of reversal of *won*. If the eight errors of *own* are omitted in computing the percentage of reversals for this sub-test, the figure for the total would be about 18 per cent instead of 20.

Two long words, *careful*, in the Gates sub-test VIII, 2, and *answer*, in the Gates sub-test VIII, 3, produced, respectively, 0 and 5 reversals. Two reversal forms were shown among the six choices for each of these words. The word *careful* was the only one among the 22 stimulus words used in these two tests that produced no reversals.

Writing small letters, Gates sub-test XIII, 3-*B*, adapted, and writing digits, Gates XIII, 3-*C*, adapted, gave 16 per cent of reversals each. Recognition of small letters, Gates IX, 9, recognizing

words seen, Gates VIII, 2, and copying forms, words, letters and digits, Metropolitan test 2, each produced 13 per cent reversals. Writing capital letters gave 8 per cent of reversals. The remaining four tests gave 2 or 4 per cent of reversals each. One reason for these small percentages was that these tests were so difficult that only a few responses were attempted by the children. Table 8, Sections 11 and 10, shows that the letters producing the largest number of reversals were the small *q*, *d* and *j* and the capital *J*.

The Metropolitan test of copying geometrical forms (Table 8, Section 1), produced only two, one, and two reversals for each of three forms. One child made two reversals, the triangle and the angle figure. The other reversals were made by different children.

In summary, the analysis of the reversals made by the children in tests of words, letters, digits and geometrical forms indicates:

(*a*) A considerable percentage of reversals, varying on different items from 0 to 76.

(*b*) Imperfect and confused learning, particularly in the case of certain letters and digits.

(*c*) The possibility that many reversals were due to carelessness or incompleteness of observation only.

(*d*) The possibility that many reversals were due to confusion or inadequacy in remembering resulting, perhaps, from carelessness or incompleteness of observation; for example, tests requiring recognizing similarities, particularly the Metropolitan and the Stone, which produced three of the four highest percentages of reversals, demanded good observation and efficient remembering.

(*e*) The probability that many reversals made by these Grade I children had already, by the time tests were made, become habit responses. The digit and letter tests, in particular, indicated this probability.

C. Analysis of Responses Made by Pupils

Table 10 shows the total number of reversals made by each child on the combined tests in letters, words and digits in the fall and spring semesters in which the tests were given. Since the spring semester tests were not included in Tables 8 and 9, the totals of Table 10 are larger than those in Table 9.

Inspection of this table shows considerable variation among the pupils in the number of reversals made, and also a good deal of

TABLE 10

PUPILS' REVERSAL RESPONSES BY TYPE OF TEST AND SEMESTER

	Letter Fall G. D.* (1)	Word Fall G. D.* (2)	Word Spring G. D.* (3)	Digit Fall G. D.* (4)	Digit Spring Metropolitan (5)	Digit Word Fall Stone (6)	Total (7)
No. of subtests	8	5	6	1	1	1	22
Pupils							
1	4	3	2	6	3	1	19
2	9	8	4	0	0	1	22
3	0	4	4	2	1	0	11
4	8	4	5	1	0	2	20
5	1	5	4	0	1	2	13
6	13	4	8	2	4	1	32
7	3	9	5	1	0	3	21
8	12	10	3	4	4	5	38
9	7	4	5	2	3	4	25
10	3	2	6	0	1	1	13
11	7	4	4	0	1	2	18
12	16	6	5	2	3	0	32
13	3	4	3	0	0	3	13
14	0	2	4	0	0	0	6
15	4	5	3	2	1	1	16
16	0	7	3	1	1	3	15
17	15	4	10	2	2	3	36
18	3	1	3	0	2	2	11
19	2	6	2	1	1	2	14
20	4	1	0	1	2	2	10
21	1	4	6	2	4	1	18
22	1	9	4	4	1	5	27
23	1	4	3	0	0	3	11
24	6	7	3	4	3	1	24
25	2	4	1	1	1	2	11
Totals	128	121	100	38	39	50	476
Average							18.2
Range							6-38

*Gates Reading Diagnosis Tests

variation in the reversals made by each child in different types of test material. While there were several children who made no reversals in some types of tests, every child made some reversals. The average number of reversals was 18.2 per child, and the range was from 6 to 38.

Table 11 gives the correlations of the reversals made on the various types of tests shown in Table 10.

The correlation of .70 between the two fall tests of digits is

TABLE 11

CORRELATIONS OF REVERSALS BY TESTS AS SHOWN IN TABLE 10

G D fall digits	Metr fall digits	70
	Group A	
G D fall letters	Metr fall digits	43
" " "	G D fall digits	40
" " words	" " "	39
" " letters	" spring words	35
" " words	Stone fall words	35
	Group B	
G D fall letters	G D fall words	23
" spring words	" " digits	18
" " "	Metr fall "	14
" fall letters	Stone " words	11
" " digits	" " "	07
" " words	G D spring words	06
" " "	Metr fall digits	03
Metr. " digits	*Stone " words*	*−.02*
G D spring words	" " "	−21
Total fall G D	Total fall Metr and Stone	29

high enough to indicate quite satisfactory reliability. These two tests were different, first, in that the digit *3* was not included in the Metropolitan test, and second, in that in the Metropolitan test the pupils wrote the numbers as answers to problems given them orally, while in the Gates test they wrote the numbers by dictation. There was also about two or three months difference in the time at which the two tests were given Both tests were given individually, but the order in which the pupils were taken for testing was not the same Each of these variables might have reduced the correlation obtained

The correlations shown in Group *A* seem to be somewhat significant in that they are about the same in size and are better than low correlations The content of the tests correlated in this group was dissimilar, being letters, words and digits. They were all given in the fall semester, however, excepting the Gates spring semester word tests Perhaps correlations of this size between tests of different content, indicate the presence of a general tendency which was operating during the fall semester. The last correlation given in the table, .29, between the total fall Gates and the total fall Metropolitan and Stone tests, may indicate the same possibility.

The correlations shown in Group *B* are markedly low. In this

group are also found correlations of tests which differ in content, excepting the Gates fall and spring word tests There are tests in this group also which in most cases were given in different semesters Perhaps the low correlations indicate the influence of specific learnings, which may have offset the effects of any previously present general tendency. The increased learning of specific words achieved by spring would help to explain satisfactorily the coefficient of 06 found between the fall and spring results on the Gates word tests.

The conclusion seems to be that there was little if any influence of a general reversal tendency among these children except for a slight effect in the fall before specific learnings had been acquired to a considerable extent

The correlations between total reversals and other errors made in three Gates letter tests—giving letter sounds, naming small letters, and writing capital letters—was 24 The correlation between reversals and the number of omissions made by the pupils on the same tests was — 09 In these letter tests the children showed no clear tendency to make more reversals as they made more errors or more omissions, although there may have been a slight relationship between number of reversals and number of errors

In the Gates letter tests, XIII, 3, adapted, in which the pupils wrote capital and small letters and digits, note was made by the examiner of strokes used by the children, which were either in reverse direction or in some other way strikingly different from the direction of strokes ordinarily used by experienced writers Comparison of the number of form reversals and these stroke reversals is shown as follows

	Form reversals	Stroke reversals
Writing capital letters	21	38
" small "	24	15
" digits	35	12
Total	80	65

It will be observed that the largest number of stroke reversals, by far, was in writing capital letters, which gave the smallest number of form reversals. On the other hand the greatest number of form reversals was in writing digits, but only 12 stroke reversals were made on them. The correlations between stroke reversals and form reversals in four different types of tests were.

TABLE 12
NUMBER OF REVERSALS MADE BY 18 CHILDREN IN GRADES I, II AND III, BY TYPES OF TESTS

Tests	Grades I Fall	I Spr	II Fall	II Spr	III Fall	III Spr
Digits						
G.D XIII, 3, Ad Writing digits	22		8		3	
Metropolitan, writing digits	30					
Progressive Achievement tests, 3 ABCE				1	1	
Letters						
G D IX, 9, Giving letter sounds	11	1	7	3	6	
" IX, 10, Recognition cap. letters	0		1		0	
" IX, 11, " sm "	13		7		0	2
" XIII, 1, writing words	5	1	2			
" XIII, 2, "	6	8	6			
" XIII, 3, " letters	25					
" XIII, 5, Ad writing cap letters	28		13		3	1
" XIII, 3, " " sm. "	22		13	14	3	1
Progressive Achievement Tests, 5C				1	1	
Words						
G.D VIII, 1, Reversible words			20		23	
" VIII, 2, Recognize word seen	23	22	19			
" VIII, 3, " " heard	49	45	31			
" IX, 1-7, Giving phonic comb	6	6	13	4	5	2
" XIII, 1, Writing words	5	1	1			
" XIII, 2, " "	7		0			
" VI, 2, Oral reading			11		4	
" VII, 1, Word list			1		1	
Progressive Achievement Tests, IA				4	4	
" " " VC				4	2	
"						6
Total	252	84	153	31	56	12

G D	writing digits	29
G D	" letters	00
G D	words, fall	— 02
G D	" spring	— 22

These observations, although quite inadequate, agree with the other more significant findings of the study, namely, that reversal responses seem to be specific learnings rather than general tendencies.

2 *Grade Variations*

a. Children followed three years

Eighteen of the 25 children studied in Grade 1 in 1933-1934 continued in the Horace Mann School through the second and third grades Table 12 shows the number of reversals made by these pupils on digit, letter, and word tests used in the three years

The blank spaces in the table mean that the various tests were not given during the semesters shown at the top of table The table shows considerable variability in the number of reversals for each grade year for the different types of tests. For example, in the fall semester of the first grade there were 0 reversals in naming capital letters, but 49 reversals in recognizing words heard. There is also seen a general decline in the number of reversals made from grade to grade, except in the Gates sub-test VIII, 1, where an increase appeared This test is made up of 30 words commonly reversed, such as *was, tap, raw, keep,* etc The table shows a rather considerable number of reversals in both second and third grades in writing digits and letters, and in giving and recognizing letter sounds. There was only one test in seven that were given each grade year, in which no reversals were made by these children when they were in Grade 3 This was in recognizing capital letters However, no reversals were made in this test when the children took it in the fall of their first grade year.

Table 13 gives the rank order positions of each pupil according to the total number of reversals made on the tests given in each of the three years The correlations between these positions is also shown.

The correlations for successive years are quite high— 661 between first and second grades and 803 between second and third grades The correlation between Grades 1 and 3, 558, is not as high as the others, but indicates considerable similarity in the tendencies

TABLE 13

RANK ORDER POSITIONS IN NUMBER OF REVERSALS BY 18 PUPILS WHEN IN GRADES I, II AND III, AND THE CORRELATIONS BETWEEN GRADE POSITIONS

	Rank order positions Grades		
Pupils	I	II	III
1	8	4	9
2	5.5	2	3.5
3	15	5	3.5
4	3	3	5
5	7	6	2
6	1	7	13.5
7	5.5	8.5	7
8	12.5	10.5	6
9	4	8.5	9
10	10.5	17.5	13.5
11	12.5	12	13.5
12	10.5	17.5	13.5
13	2	1	1
14	17	13.5	17.5
15	14	15.5	13.5
16	17	13.5	17.5
17	9	10.5	9
18	17	15.5	13.5

Correlations between grade positions

I : II	.661
II : III	.803
I : III	.558

of the children to make reversals at these two school years. The count of reversals was not made on identical tests in the three grades as is shown in Table 12. Some tests were used in Grade 3 that were not used in Grade 1. Several tests that were used in Grade 1 were not used in Grade 3. There was much more similarity of tests between Grade 2 and each of the other grades. This may account largely for the relatively high correlations shown between Grade 2 and the other grades, and the relatively lower correlation between Grades 1 and 3. In so far as these higher correlations were produced by identity of test items it would signify that specific reversal habits, rather than general tendencies to make reversals, may have persisted for many months. As incorrect specific habits disappeared the correlations would tend to decrease.

Seven types of tests were repeated each year and the correlations of the number of reversals made by the 18 children in those types of tests are shown in Table 14.

TABLE 14

CORRELATIONS OF TOTAL NUMBER OF REVERSALS MADE IN 7 TYPES OF TESTS BY 18 CHILDREN OVER A PERIOD OF THREE YEARS

Grades	Semesters	Test types	(1)	(2)	(3)	(4)	(5)	(6)	(7)
I	Fall	Letters	(1)	.32	07	.49	.58	.31	06
	"	Digits	(2)		— 01	27	.40	— 10	— 10
	"	Words	(3)			.04	30	—.02	11
	Spring	"	(4)				.47	88	62
II	Fall	Letters	(5)					45	30
	"	Words	(6)						71
III	"	"	(7)						

The seven highest correlations in the above tabulation are:

I Spring words	(4)	II Fall words	(6)	88
II Fall words	(6)	III " "	(7)	71
I Spring words	(4)	III " "	(7)	62
I Fall letters	(1)	II Fall letters	(5)	58
I " "	(1)	I Spring words	(4)	49
I Spring words	(4)	II Fall letters	(5)	.47
II Fall leters	(5)	II Fall words	(3)	45

The lowest six correlations are

I Fall letters	(1)	I Fall words	(3)	07
I " "	(1)	III " "	(7)	06
I " words	(3)	I Spring words	(4)	04
I " digits	(2)	I Fall words	(3)	— 01
I " words	(3)	II " "	(6)	—.02
I " digits	(2)	II " "	(6)	— 10

In general it seems that when the tests tested much the same items, as I spring words and II fall words, the correlations were high; whereas when the tests involved many dissimilar items or when they were separated in time by some months (except in the case of the summer months wherein presumably little specific learning of symbols was acquired) the correlations tended to be low. This fact further indicates the conclusion that tendencies to reversal responses were specific rather than general. Where the material differed the specific learnings differed. Where the material was similar but time intervened, specific learnings would have tended to correct early formed habits to reverse a symbol. In particular, the correction of inaccurate learnings during the first grade would materially have affected relationships between Grade I fall reversals and later reversals in the spring or in Grade II.

TABLE 15

PERCENTAGE OF CHILDREN MAKING REVERSALS BY GRADES AND SEMESTERS TESTED

Level	4 yr Kdn		5 yr Kdn		5 yr Kdn		Grade I											Grade II								GRADE III		
Year	1935-36		1934-35		1935-36		1933-34		1934-35		1934-35			1935-36				1934-35				1935-36				1935-36		
Semester	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S
No. of pupils	21	21	54	48	48	46	25	25	31	31		28	26	25	25	24	30	30		25	28	28	24	24	29	28	28	24
DIGITS																												
Gates Diagnosis	38	43	69		44	67	68			74		86	77	36	62	54	27			20	43	11	50	12	7		0	4
Metropolitan							76																					
Progressive Achievement																						25		21				8
LETTERS																												
Gates Diagnosis																												
Giving letter sounds	10	14		18	19	9	40			45		29	54		42	12	30	17		44	57	4	54	4	38		46	
Naming capital letters	19		22	0	12	7	0			13		4	4		4					0	7		6					
Naming small letters	10	24	61	43	15	20	44			58		61		18	12	17	27			36	4		0	7		4		8
Writing capital letters	24	14	57	50	42	29	60			45		89	54	11	21	12	43			44	32	4	42	17	14	7	36	4
Writing small letters	19	29		30	19	47	52			48		82	35	39	21	29	40	33		52	36	13	46	12	10	11	29	4
WORDS																												
Gates Diagnosis																					50	46			38		25	
Reversible words																												
Recognizing words seen							72	60		77																		
Recognizing words heard							92	88		87																		
Giving phonic combinations							28	24		58		7		14		12	33	30			11	11	53	0	38	11	14	4
Oral reading																	27				43			42	21		7	
Word recognition																					17							
Progressive Achievement																												
T-A																							3	16	17		25	
5 C																17		20					4	[illegible]	7		21	

TABLE 16

NUMBER OF REVERSALS MADE BY GROUPS AND TESTS

Level	4 yr Kdn		5 yr Kdn		5 yr Kdn		Grade I											Grade II								Grade III		
Year	1935-36		1934-35		1935-36		1933-34		1934-35		1934-35		1935-36					1934-35				1935-36				1935-36		
Semester	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S
No. pupils	21	21	54	48	48	46	25	25		31		28	26	23	25	24	30	30		25	28	[illegible]	25	25	29	26	28	24
DIGITS																												
Gates Diagnosis	15	17	96		53	83	38			57		47	54	30	48	43	12	1		8	30	3	22	1	3		8	1
Metropolitan							30																					
Progressive Ach't																					20			10	21		13	2
LETTERS																												
Gates Diagnosis																												
Giving letter sounds	2	3		13	9	4	14	1		21		9	16		11	3	10	5		13	16	2	23	1	11		13	
Naming capt'l letters	4		15		6	3	0			4							0				2	1						
Naming small letters	2	9	70	59	7	14	17			28				8	3	5	13			9	1			7		2		3
Writing cap'l letters	11	5		47	22	13	30			24		30	16	4	5	4	18			18	9	1	11	4	4	2	10	1
Writing small letters	7	10		27	12	27	27			30		34	11	13	5	9	19	18		10	11	6	12	3	4	1	8	2
WORDS																												
Gates Diagnosis																												
Reversible words																												
Recognizing words seen							29	27		47							29				25			24	37		11	
Recognizing words heard							66	61		67																		
Giving phonic combinations							13	11		33		3		4		3	19	11	11		3	3			10	3	5	1
Oral reading																	17				5			19			2	
Word recognition																	2				4						1	
Progressive Achievement																												
1 A																		7		7	17			6	7		7	
5-C																		5		1	1			4	2		7	
5-D																										13		16

b. Grade trends

Two tables show the reversal tendencies comparatively from the four-year kindergarten group through the third grade.[3] Table 15 gives the percentages of children making reversals by groups and by tests. Table 16 gives the average number of reversals made per pupil by grade groups and by tests. The blank spaces in the tables indicate that the various tests were not given during the semesters shown at the top of the tables. Zero's show that the tests were taken but that no reversals were made The two tables show the same general tendencies noted above in connection with the 18 children tested over three years, namely: much variability in reversals on the different tests and a considerable persistence of some reversal responses into the third year.

The inclusion of data from the three kindergarten groups adds evidence that the beginnings of specific reversal responses for the more than 400 children studied in this investigation, was probably long before Grade 1. The percentages for kindergarten and the grade groups shown in the tables are not strictly comparable, because the amount of acquired learnings varied greatly between the groups. The figures seem to show an increase in reversal responses from the four-year kindergarten group through the fall semester of Grade 1 in most of the tests used in those grades. But this apparent trend does not mean that the children tended proportionately to make more reversals as they grew older It is true, rather, that *in proportion to the number of digits and letters known and attempted* the kindergarten children made a greater number of reversals than the Grade 1 children.

The percentages of pupils in the third grade who in the fall made reversals in giving letter sounds and in writing capital and small letters seems quite high in view of the fact that the reversals made were limited almost entirely to the few well-known reversible letters—*b, d, p, q, j* and *z* The tables also show a sharp drop from fall to spring in all reversals in Grade 3, except digit reversals which were very few during both semesters.

The data in the study give no clues as to what causes children to make reversal responses when they begin to learn symbols Common

[3]For the general ability of these grade groups see Footnote 2.

sense reasoning, however, consistent with the general conclusion of this investigation that reversals are explainable as specific learnings rather than the result of general tendencies, would suggest that incomplete observation and perhaps other faulty learning processes account for reversal responses. Reading and writing alone involve the unique requirement of attending to symbols in the arbitrary left to right order. For this reason it is quite possible, as has commonly been held, that giving attention to symbols from right to left, or from below up, or from above down, might result in confusion in learning. More plausible interpretation of the usual difficulties, however, seems the explanation that the great variety, complexity, and confusing similarities and dissimilarities of symbols would inevitably lead to confusion in learning what they are and how to write them.

It is probable that most teachers far underestimate the long and difficult processes involved in mastering these symbols. There are over 52 printed letter symbols, all varied by printed and especially by written styles. To learn all these forms, with their names and sounds, is so difficult that it should rarely be left to chance, incidental, or concomitant learning. That difficulty in learning them is real was attested to by observation of kindergarten and Grade 1 children during the tests. The examiners were impressed with the intense effort put forth by most of the children in trying to name or write letters. The effort was often painful to observe—alternating squirming and tension, sustained frowning, panting, grunting, whispering and muttering, even weeping.

The practical conclusions indicated by the findings of the study seem to be that children need careful guidance in learning letter and number symbols, and that for most children like the Horace Mann groups studied, need for this guidance begins long before Grade 1, and for some children probably continues for a considerable time after Grade 1.

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CORRELATIONS OF READING PROGRESS WITH OTHER ABILITIES AND TRAITS IN GRADE I*[1]

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INTRODUCTION

During the school year 1933-34 a variety of tests was given to 25 children in Grade I of the Horace Mann School, Teachers College These included tests of "reading readiness", many of the Gates *Reading Diagnosis Tests*, some reading achievement tests, mental ability tests, such as the Stanford Revision of the Binet-Simon tests and various performance tests, certain psychological tests, as of perception and perseveration; and several measures of psycho-physical and personality traits and of home background The purpose of the study was to examine any possible relationships that might exist between measurable traits and abilities, and early progress in the mechanics of reading

The children of the group came from well-to-do homes A large percentage of the parents were professional people The following averages for these pupils were found

Chronological age (Jan 1, 1934)	6 31
Mental age (Jan 1, 1934)	7 61
Intelligence quotient	120 6

Nearly every test and measurement was given or made individually, under carefully controlled conditions, and by reliable persons accustomed to administering tests to young children The co-

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[1]This report presents a minor phase of a study of Reading Readiness and Reading Progress in the Primary Grades of the Horace Mann School, Teachers College, New York, 1933-1937 This study has been made possible by the cooperation of Miss Agnes Burke, Teacher of Grade 1, and other teachers of Kindergarten and Primary Grades It has been made under the supervision of Doctor Cecile White Flemming, Director of Pupil Individual Development and Guidance, and of Doctor Rollo G Reynolds, Principal Prepared with the assistance of the U S Works Progress Administration, New York City, Project No 165-97-6172, Sub-Project 4

operation of the pupils was almost invariably excellent It is believed for these reasons that errors of examination were unusually low

The tests and measures are grouped under five categories 1) reading tests; 2) tests of abilities with letters and phonic combinations; 3) measures of mental ability, 4) psycho-physical measures; 5) measures of personality traits and characteristics The classification of a test in any given category was arbitrary, and was determined solely on logical grounds, based upon informal and common-sense meanings and upon study of the tests

Objections may be made by critical readers to the classification of certain of the tests. The following explanations are offered in regard to some sub-classifications and are based upon analyses of the nature of the tests and of the responses of the children to them

1 The category "tests of abilities with letters and phonic combinations"

(*a*) The Gates *Reading Diagnosis Tests*, Subtests VIII 2 and 3, *Word Recognition*, were primarily letter recognition tests for most of the grade one children tested. Evidence for this was found in several respects, as follows: the choice of wrong answers in these two tests was very much greater for those wrong words that began with the same letter as did the correct words, than for any other wrong words; nearly every child spelled out the words as he hunted along the line of words looking for the correct one, except in cases of instant recognition.

(*b*) Writing words was, basically, a letter knowledge test,

(*c*) The Stone and Grover *Classification Test* was really a letter perception test, since it required the subject to indicate whether observed words were the same or different,

(*d*) Van Wagenen *Reading Readiness Test*, subtest *Word Discrimination*, was, basically, a letter perception test for much the same reasons as the Stone and Grover *Test*.

2. The category, "measures of mental ability":

(*a*) The Metropolitan *Reading Readiness Tests, Total*, and subtest for numbers were largely general mental ability tests, as indicated by correlations of 79 and 80, respectively, with Stanford-Binet mental age The subtests for vocabulary, information, and man drawing, although they gave only fair and low correlations with Stanford-Binet mental age, seem by content to have been mental ability measures, rather than tests of special learned skills

(*b*) The Van Wagenen *Reading Readiness* subtests of information, vocabulary, relations and memory span, were basically tests of general mental ability, for much the same reasons as given above

3 The category "measures of personality traits and characteristics": *Reversals, errors, and omissions* were put into this category with the belief that they reflect aspects of personality rather than measure reading, letter or mental abilities, with which they tended to give low or zero correlations.

The data of the study are in terms of correlations obtained by

the rank order method. To secure the rank orders all measures and appraisals which originally were scored otherwise, were transmuted into numerical orders. A total of 1,857 correlations are included in this summary. Owing to lack of facilities it was not feasible to make all the computations that were possible. A "finder" device was used to select for computation the correlations which seemed to promise significance. It is believed that through the use of this device, all the high and fairly high correlations were found. The correlations not computed would probably have been below .50, and most of them probably nearer zero than .50. The P.E.'s of rhos when N is 25, range from ±.0237 for rho .90, to ±.1335 for rho .10, as indicated in the following list of representative P.E.'s:

Rho	P.E.	Rho	P.E.
.90	= ±.025	.40	= ±.112
.80	= ±.046	.30	= ±.122
.70	= ±.066	.20	= ±.129
.60	= ±.083	.10	= ±.134
.50	= ±.099		

The validity of many of the measures and appraisals is uncertain. Few correlations of seemingly unusual size were obtained, however, and few which were inconsistent with other correlations for the same kind of traits and abilities found in the study. The opinion of the teacher, of the school psychologist, and of other qualified persons who have studied the figures, is that the results have quite high validity.

A. Correlations by Categories

Table 1 presents, by categories, the averages of the correlations of the 14 various reading tests with each of the other subtests. There is also given in Part A of the table, the average and standard deviation of the 91 intercorrelations of the 14 reading tests. The high average of these intercorrelations, .728, and the relatively low standard deviation, ±.131, indicate quite high reliability and validity for these reading measures.

Part B of the table gives the averages of the correlations of reading with 30 letter tests, arranged by size of the averages. The total 361 rho's averaged .515, with a standard deviation of ± .185. This average was the highest for all the categories. The separate

TABLE 1

AVERAGES OF CORRELATIONS OF FOURTEEN READING TESTS WITH OTHER TESTS AND MEASURES OF CATEGORIES

Names of tests used, numbered in the order shown in the intercorrelation form below

1 Gates Primary Reading Tests, Type 1, word recognition, November
2 Gates Primary Reading Tests, Type 1, word recognition, March
3 Gates Primary Reading Tests, Type 2, sentences, March
4 Gates Primary Reading Tests, Type 3, paragraphs, March
5 Hildreth, First Grade Reading Analysis Test, matching phrases, Mch
6 Hildreth, First Grade Reading Analysis Test, matching words, Mch
7 Hildreth, First Grade Reading Analysis Test, matching sentences, Mch
8 Hildreth, First Grade Reading Analysis Test, matching words and phrases in sentences, March
9 Hildreth, First Grade Reading Analysis Test, total, March
10 Teacher's ranking of pupils in November, prediction of progress during year
11. Teacher's ranking of pupils in May, progress achieved
12 Gates Primary Reading Tests, Type 1, May
13 Gates Primary Reading Tests, Type 2, May
14 Gates Primary Reading Tests, Type 3, May

Part *A* Intercorrelation of reading tests

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		75	60	69	34	.41	58	58	53	70	68	72	79	62
2			.62	.64	46	.56	65	83	70	70	85	76	81	76
3				92	63	60	70	.79	75	83	89	86	78	84
4					39	55	65	70	62	.76	74	79	74	75
5						51	60	52	68	.62	61	.51	49	56
6							.79	75	.93	67	66	76	66	77
7								68	.86	.60	.68	73	69	.70
8									86	.81	94	.89	83	89
9										.79	82	85	78	84
10											86	86	76	85
11												.90	.87	91
12													89	92
13														84
14														

Number of intercorrelations of above reading tests	91
Average of intercorrelations of above reading tests	728
Standard deviation	± 131

TABLE 1 (Cont'd)

Part B. Averages of computed correlations of the fourteen reading tests and thirty tests in the category, "Tests of Abilities with Letters and Phonic Combinations"

Letter tests used	Number of rho's computed	Averages
*G. D. IX, Total 1-7, phonic combinations and IX, 9 giving letter sounds, spring		
G. D. IX, 1-7 and 9, fall	2	815
G. D. IX, 1-7, giving phonic combinations, fall	11	723
G. D. XIII, 1-2, writing words, spring	14	701
G. D. IX, 1-7, giving phonic combinations, spring	10	692
G. D. VIII, 3, word recognition, auditory perception, spring	10	678
G. D. IX, 9, giving letter sounds, spring	9	659
G. D. XIII, 1-2, writing words, fall	10	655
G. D. IX, 9, giving letter sounds, fall	14	616
G. D. VIII, 3, word recognition, auditory perception, fall	14	607
G. D. IX, 11, naming small letters, fall	14	602
G. D. XIII, 3, writing letters, fall	14	594
Letters, total, from various letter tests, fall	14	583
G. D. XIII, 3, adapted, writing capital and small letters and digits, spring	14	581
Stone & Grover, Classification Test for Beginners in Reading, total, fall	10	581
G. D. X, 2, recognizing sounded letters, spring	14	578
G. D. XV, 2, memory span, letters, fall	10	550
G. D. X, total, fall	12	538
G. D. VIII, 2, word recognition, visual presentation, fall	8	490
Stone & Grover, Classification Test for Beginners in Reading, I, fall	14	483
G. D. IX, 10, naming capital letters, fall	14	466
Stone & Grover, Classification Test for Beginners in Reading, II, fall	14	464
G. D. X, 1, blending sounds, spring	12	449
G. D. X, 3-4, giving initial and final sounds, fall	10	427
Van Wagenen Reading Readiness Test, word discrimination, fall	14	401
G. D. X, 2, recognition sounded letters, fall	14	396
G. D. VIII, 2, word recognition, visual presentation, spring	14	.381
G. D. X, 1, blending sounds, fall	9	377
G. D. XI, 2, same—different words, fall	14	340
G. D. XI, 2, same—different words, plus supplement, fall	11	203
	14	126
Totals 28	361	
Average		515
Standard deviation		±185

*Gates Reading Diagnosis Tests

TABLE 1 (Cont'd)

Part *C* Correlations of the fourteen reading tests and twenty-one tests in the category, "Measures of Mental Ability"

Mental measures	Number of rho's computed	Averages
Van Wagenen Reading Readiness Test, Information, fall	14	604
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, total, fall	13	599
Binet mental age (Stanford Revision)	14	511
G D XV, 1-4, total memory span, fall	14	481
Mare and Foal, Time, Healy-Fernald, fall	9	470
Healy Picture Combination Test, II, fall	7	451
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, Numbers, fall	14	426
Do, drawing man, fall	11	372
Do, vocabulary, fall	14	361
G D, XI, 1, repeat nonsense syllables, fall	14	352
Van Wagenen Reading Readiness Test, Vocabulary, fall	14	.342
Binet Intelligence Quotient (Stanford Revision)	14	333
Van Wagenen Reading Readiness Test, Relations, fall	14	.311
Total vocabulary, spring	5	.310
Van Wagenen Reading Readiness Test, memory span, fall	14	.298
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, Information, fall	12	244
Do, Sentences, fall	13	.233
Ship Test, Pintner-Patterson, fall	4	225
Manikin Test, Pintner-Patterson, fall	3	170
Seguin form board, time, fall	5	.138
Mare and Foal, Healy, Fernald, Errors, fall	5	.096
Total 21	225	
Average		369
Standard deviation		± 162

Part *D* Correlations of the fourteen reading tests and eleven measures in the category "Psycho-physical Measures"

Psycho-physical measures	Number of rho's computed	Averages
Vocabulary, total, time, spring	3	337
Chronological age, Jan. 1, 1934	14	293
G D XIII, 3, adapted, writing capital and small letters and digits, time, spring	2	235
Perception, exposure of 32 cards, original, spring	9	227
Perseveration, Elkin-Maller, Attention Test, spring	14	.222
Nutrition, variation from height-weight-age norms, fall	7	087
Height, fall	6	083
Grip, hand dynamometer	14	—.024
Weight, fall	6	— 037
Motor coordination, six tests, spring	14	— 076
Number of activities, total, parents' report, spring	3	— 117
Total 11	97	
Average		099
Standard deviation		± 188

TABLE 1 (Cont'd)

Part *E*. Correlations of the fourteen reading tests and eight measures in the category "Measures of Personality Traits and Characteristics"

Traits and Characteristics		Number of rho's computed	Averages
Personal traits, parents' reports, spring		5	125
Reversals, visual perception, letters, digits, words, numbers		14	062
Reversals, auditory presentation letters, digits, words, numbers		14	024
Personality rating, Hicks, "A Personality Rating Scale for Children Six to Nine," parents' reports, spring		5	013
Undesirable behavior and traits, parents' reports, spring		5	— 107
Nervousness index, parents' reports, spring		1	— 140
Totals	6	44	
Average			057
Standard deviation			± 098
Errors, total, nine tests		7	624
Omissions, total, nine tests		9	633
Grand total	8	60	

averages of the correlations of the reading tests with phonic combinations and some of the other letter tests were also among the highest correlations found in the study. Ten of the 361 correlations of individual reading tests and individual letter tests were .80 or over, 49 were .70 to .79. The highest of all was .84, that of the teacher's May judgment of the children's ability to read and a late fall test of the children's ability to give phonic combinations.

Part *C* gives the averages of the correlations of reading with 21 mental tests. The entire 225 computed correlations averaged .369, with a standard deviation of ± .162. The several averages were considerably lower than those involving reading and letters.

Part *D*, for reading and psycho-physical measures, and Part *E*, for reading and personality measures, show averages that were practically zero. In Part *E* the correlations of reading with errors and omissions have been shown separately because the figures for them were so high. The higher correlations with errors and omissions were largely due, perhaps, to the fact that most of the tests used for counting errors and omissions were reading or reading diagnosis

TABLE 2

AVERAGES OF CORRELATIONS OF THIRTY LETTER TESTS WITH OTHER MEASURES BY CATEGORIES

Part *A* Intercorrelations of letter tests.		Number of rho's computed	Averages
Names of letter tests shown in Table 1, Part *B*			
Totals	30	156	
Average			535
Standard deviation			± 169
Part *B* Averages of computed correlations of thirty letter tests and twenty tests in the category, "Measures of Mental Ability"			
Mental tests used			
Gates Reading Diagnosis Tests, XI, 1, Repeat nonsense syllables, fall		9	530
Van Wagenen Reading Readiness Tests, Relations, fall		6	.523
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, Vocabulary, fall		6	503
Gates Reading Diagnosis Tests, Total XV, 1-4, Memory span, fall		17	.494
Van Wagenen Reading Readiness Test, Vocabulary, fall		8	490
Van Wagenen Reading Readiness Test, Memory span, fall		7	484
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, total, fall		12	472
Ship test, Pintner-Patterson, fall		1	470
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, numbers, fall		11	470
Do, Drawing man, fall		6	455
Van Wagenen Reading Readiness Test, Information, fall		3	450
Hildreth, Griffith, Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, Information, fall		4	388
Healy Picture Completion Test, II, fall		1	330
Hildreth, Griffith Orleans, Metropolitan Readiness Test for Kindergarten and Grade I, Sentences, fall		2	330
Mare and Foal, Healy-Fernald, time, fall		12	322
Vocabulary, spring		15	305
Mare and Foal, errors, fall		4	185
Seguin form board, time, fall		13	.175
Total	18	137	
Average			416
Standard deviaton			± 163
Mental Age, Stanford Revision Binet-Simon, Jan 1, 1934		30	459
Intelligence Quotient, Stanford Revision Binet-Simon, Jan 1, 1934		30	383
Total	20		

TABLE 2 (Cont'd)

Part *C* Averages of computed correlations in thirty letter tests and nine measures in the category "Psycho-physical measures"

Psycho-physical measures	Number of rhos	Averages
Gates Reading Diagnosis Tests, XIII, 3, adapted, writing capital and small letters and digits, time, fall	10	442
Vocabulary, time, fall	3	363
Perseveration, Elkin-Maller, Attention Test, spring	18	235
Tapping, Whipple and Healy, spring	5	182
Chronological age	21	124
Perception, exposure of 32 cards, original	20	063
Developmental index (babyhood), parents' reports	8	—090
Steadiness, hole apparatus	1	—140
Motor coordination, battery of six observations and tests, spring	1	—220
Total 9	87	
Average		147
Standard deviation		± 216

Part *D* Averages of computed correlations of thirty letter tests and eight measures in the category "Measures of Personality Traits"

Personality traits	Number of rhos	Averages
Personal traits, parents' reports, spring	8	141
Reversals, visual perception, letters, digits, words, numbers	20	.098
Reversals, auditory perception	20	062
Personality Rating, Hicks, "A Personality Rating Scale for Children Six to Nine," parents' reports, spring	8	048
Undesirable behavior and traits, parents' reports	8	—081
Nervousness Index, parents' reports, spring	1	—090
Total 6	65	
Average		050
Standard deviation		± 169
Errors, total, nine tests	6	565
Omissions, total, nine tests	2	550
Total 8		

tests The children who read the best quite obviously should have made the fewest errors and omissions

Table 2 presents, by categories, the averages of the correlations of the various tests of letter abilities with the other individual tests and measures Part *A* gives the average and standard deviation of the 156 intercorrelations of the letter tests The average, 535, while lower than that for the reading tests is rather impressive The letter tests were very varied, as perusal of their descriptions

in Table 1, Part *B*, clearly indicates. One would not have expected high correlations between, say, memory span for letters and recognition of letter sounds. The correlation *actually found* was .11 On the other hand, self-correlation of fall and spring tests of phonic combinations was 74.

Part *B* of Table 2 gives the averages of the correlations of letter tests with 20 mental tests and at the bottom of the list, the average of 30 correlations of letter tests with Stanford-Binet mental age and 30 correlations of letter tests with Stanford-Binet intelligence quotient. The average of the 137 correlations was .416. The averages for the correlations of the letter tests with mental age and intelligence quotient were .459 *and* 383, *respectively* The highest single correlation was 75, between mental age and ability to give letter sounds, the latter test having been given by means of visual presentation of the small letter forms This test required both ability to recognize small letter forms and knowledge of their sounds. On the whole Part *B* indicates only very moderate relationships between the abilities measured by letter tests and those measured by mental tests

Part *C* gives the averages of the correlations of the various letter *tests with nine psycho-physical measures.* The 87 *correlations* averaged .147 and gave a standard deviation of ±.216 There were but two coefficients above .50, namely 66 for the correlation of the number of letters of the alphabet written and the time taken to write them, and 54 for the correlation of a score for a combination of letter tests and the time taken to write letters, which was one of the tests included in the combination. These coefficients would be high necessarily because of the great extent of identity in the responses compared The great variability and low coefficients of the other correlations indicate few, *if any, significant relationships* between letter abilities and the psycho-physical measures used

Part *D* gives the averages of the correlations for letter tests with eight personality measures Errors and omissions have been shown separately, because they produced considerably higher coefficients than the other personality measures, averaging 565 and 550, respectively The coefficients for the other tests were practically zero The 65 coefficients gave an average of 05, standard deviation ±.169.

Table 3 presents, by categories, the averages of the correlations

TABLE 3

AVERAGES OF CORRELATIONS OF TWENTY-ONE MENTAL TESTS WITH OTHER TESTS AND MEASURES, BY CATEGORIES

	Number of rhos	Averages
Part A Intercorrelations of mental measures		
Names of mental tests are given in Table 1, Part C		
Total 21		
Average	129	462
Standard deviation		± 189
Part B Averages of computed correlations of twenty-one mental measures and sixteen measures in the category, "Psycho-physical measures"		
Psycho-physical measures		
Steadiness, hole apparatus	5	440
Gates Reading Diagnosis Tests, XIII, 3, adapted, writing capital and small letters and digits, fall	9	259
Vocabulary, time, spring	6	.198
Tapping, Whipple and Healy, spring	5	164
Number of activities, indoor, parents' reports, spring	2	160
Developmental index, babyhood, parents' reports, spring	8	153
Number of activities, total, parents' reports, spring	2	125
Perception, exposure of 32 cards, original	21	116
Chronological age	20	.108
Perseveration, Elkin-Maller, Attention Test, spring	21	074
Height, fall	8	056
Number of activities, outdoor, parents' reports, spring	2	055
Grip, hand dynamometer	9	032
Motor coordination, battery of six observations and tests, spring	8	010
Weight, fall	8	— 120
Nutrition, variation from height-weight-age norms	8	— 122
Total 16		
Average	142	096
Standard deviation		± 217
Part C Averages of computed correlations of twenty-one mental measures and ten measures in the category, "Measures of Personality Traits and Characteristics"		
Personality measures		
Number of children's books in home, parents' reports, spring	2	250
Number of magazines and newspapers in home, parents' reports, spring	2	.230
Reversals, visual perception, letters, digits, words, numbers	21	117
Reversals, auditory perception, letters, digits, words, numbers	21	074
Personality rating, Hicks, "A Personality Rating Scale for Children Six to Nine," parents' reports, spring	10	071
Personal traits, parents' reports, spring	10	— 057
Nervousness Index, parents' reports, spring	6	— 073
Undesirable behavior and traits, parents' reports, spring	10	— 103
Total 8		
Average	82	046
Standard deviation		± 205
Errors, total nine tests	9	603
Omissions, total nine tests	2	205

of 21 mental tests with the other individual tests and measures not already shown in the previous tables Part *A* shows the average of the 129 intercorrelations of the mental tests to be 462, with a standard deviation of 189 The average was not high and the variability was large This is what would be expected, however, as a reading of the descriptive names of the mental tests shown in Part C of Table 1, would indicate great variation in the abilities tested. For example, one would hardly expect a high correlation between a vocabulary test and the Goddard form board, the coefficient for which in this study was — 11 On the other hand, certain relationships found were about what one might have expected: for example, the correlation between the Mare and Foal time and error scores was, 70, that between mental age and the Metropolitan sub-test for numbers, .80, and that between the Van Wagenen sentence memory span test and the Gates Reading Diagnosis total memory span test, .68

Part *B* of Table 3 gives the averages of 142 correlations of mental tests and 16 psycho-physical measures The average of all together, .096, was practically zero, and the standard deviation, 217, was very large. Only one coefficient was over 50, namely: 59 for steadiness and Van Wagenen information. The three other computed coefficients involving the steadiness test were with Metropolitan information, .43, with manikin, 39, with Metropolitan total, 37, with Metropolitan numbers, 34 These coefficients are not high and are of dubious significance The "finder" device indicated that none of the other 17 coefficients of the steadiness test with mental measures would probably be as high as the five that were worked out, and so they were not computed It does not seem probable that any relationships between "steadiness" as tested, and other measured psychophysical abilities existed which would be particularly significant No relationships of importance between the mental tests and the other measures of mental abilities in this group were indicated either by the averages or by the various separate coefficients

Part *C* gives the averages of the correlations of mental tests with 10 personality measures The 82 coefficients averaged .046, standard deviation ± 205 With the exception of the correlations of errors with mental tests, .603, no significant relationships were indicated. There seemed to be a definite tendency for the more mentally

competent children to make fewer errors There did not seem to be any marked tendency for the more competent to make fewer omissions, as shown by the coefficient of 205

Table 4 presents the results for the 16 psycho-physical measures used in the study and 10 personality measures. Part *A* gives the average of 55 intercorrelations of the psycho-physical measures, —.099, standard deviation, ± 230, and the average of 22 intercorrelations of ten personality measures, 114, standard deviation ± 175 One would not expect to find high intercorrelations in

TABLE 4

AVERAGES OF COMPUTED CORRELATIONS OF SIXTEEN PSYCHO-PHYSICAL MEASURES WITH OTHER TESTS AND MEASURES

		Number of rhos	Averages
Part *A* Intercorrelations of sixteen psycho-physical measures			
Names of psycho-physical measures shown in Table 3, Part *B*			
Total	16	55	
Average			— 099
Standard deviation			±.230
Part *B* Intercorrelations of ten measures of personality traits and characteristics.			
Names of personality measures shown in Table 3, Part *C*			
Total	10	22	
Average			114
Standard deviation			± 175
Part *C* Averages of computed correlations of phycho-physical measures and personality measures			
Personality measures			
Number of children's books in home, parents' reports, spring		2	.265
Undesirable behavior and traits, parents' reports, spring		12	164
Personal traits, parents' reports, spring		12	158
Omissions, total, nine tests		2	150
Personality rating, Hicks, "A Personality Rating Scale for Children Six to Nine," parents' reports, spring		12	149
Reversals, auditory perception, letters, digits, words, numbers		8	139
Nervousness index, parents' reports, spring		4	115
Errors, total nine tests		5	082
Reversals, visual perception, letters, digits, words, numbers		10	059
Number of magazines and newspapers in home, parents' reports, spring		2	035
Total	10	69	
Average			130
Standard deviation			± 185

either of these groups of tests, since in each the abilities and traits measured were extremely varied and special The highest separate intercorrelation was .69 for height and weight, a reasonable figure. The next highest separate intercorrelation was —.48, which was for chronological age and number of activities engaged in by the children outside of school. A negative relationship between age and number of play activities has been found by Witty and Lehman in their study of older children's play, and might well enough be true of the children of this study All the other intercorrelations were below 48, and most of them were between 30 and 00, indicating very little if any significant relationships between the measures used.

Part *C* of Table 4 gives the averages of the computed correlations of the psycho-physical measures with the 10 personality measures The average of the 69 correlations, .130, was practically zero, and the standard deviation, ±.185, was very large The highest separate correlation was 51 for weight and personal traits The next highest was .49 for number of activities and personality rating by Hick's scale Grip gave a correlation of 45 with undesirable behavior and traits. It also correlated 43 with auditory reversals. Perseveration gave a correlation of 43 with number of children's books in the home All the other computed coefficients were still lower, most of them very low It seems that no significant relationships were indicated between the psycho-physical and personality measures used

Table 5 shows, for convenient comparison, the various averages by

TABLE 5

COMPARISON OF AVERAGES OF THE CORRELATIONS BY CATEGORIES

	Reading	Letters	Mental	Psycho-Physical	Personality
Reading		52	37	10	06
Letters	52		.42*	.15	05
Mental	.37	42		10	.05
Psycho-Physical	10	15	.10		13
Personality	06	05	05	13	

*Stanford Binet mental age and intelligence quotient correlations were not included in this average They averaged 16 and .38 respectively, with letters *See Table 2, Part D.*

**Stanford Binet mental age and intelligence quotient averaged 51 and .33, respectively, with the 14 reading tests See Table 1, Part *C*

categories. Of all the measures used, reading and letters seemed to have been most closely related. Mental abilities showed some relationship to both reading and letters. None of the other groups indicated significant relationships.

B. Partial Correlations

The question logically arises as to the part that mental ability may have played in the relationships found between abilities with letters and reading ability. These relationships were investigated by extending the study the next year to two other first grades and to a group of 56 five-year-old kindergarten children, and applying the formula for partialing out, separately, the effects of mental age and intelligence quotient. Table 6 gives these results for the kindergarten group.

TABLE 6

Partial Correlations between Reading and Letter Measures with Stanford-Binet Mental Age and Intelligence Quotient Constant, for Five Year Old Kindergarten Children

Letter tests	G. P. R. *Spring 1st order correlations	*2nd order correlations* M.A. constant	I.Q. constant	N
Naming small letters, fall	79	728	765	48
Naming small letters, spring	79	738	764	48
Writing small letters, spring	70	712	689	48
Naming capital letters, fall	66	560	613	46
Naming capital letters, spring	.49	.375	417	48
Writing capital letters, spring	63	539	.581	48

*Gates Primary Reading Tests, Type 1, word recognition.

In this group of kindergarten children the correlations between reading abilities as measured by word recognition tests, and abilities to name and write small letters, remained relatively high with either mental age or intelligence quotient partialed out. The partial correlations between reading and capital letters, however, were not nearly as high as those for small letters. The use of lower case type in the reading tests probably explains why those letters were so much more closely related to reading than were the capital letters, which did not appear in the reading tests used.

Table 7 for the five-year-old kindergarten pupils gives a comparison of correlations between reading and three-letter tests with six other measures partialed out, and indicates that mental age and

TABLE 7

Partial Correlations between Gates Primary Reading Tests, Type 1, Word Recognition, and Two Letter Tests with Various Other Measured Abilities Held Constant, Five Year Old Kindergarten Children

	G P R *spring with naming small letters, spring N = 48	G. P R *fall Recognizing words seen, fall N = 46	G P R *fall Naming small letters, spring N = 46
First order	79	49	
Other measures held constant			
Vocabulary	788	518	709
Sequin formboard	778	.524	719
Mare and foal, time	786	515	706
Manikin	792	520	716
Chronological age	803	449	708
Stanford-Binet mental age	738	.431	607
Stanford-Binet intelligence quotient	.764	514	688
Weight	768	478	717

*Gates Primary Reading Tests, Type 1, word recognition

intelligence quotient had no more effect upon the relationship between letter abilities and reading, than did weight, chronological age, vocabulary, or the three measures of mental ability named in the table

Table 8 shows that in Grade 1 the relationship between abilities

TABLE 8

Partial Correlations between Reading and Letter Measures with Mental Age and Intelligence Quotient Constant, 83 Grade One Pupils

	G P. R *spring					
	Type 1, Word recognition			Type 3, Paragraph reading		
	1st order	M A constant	I Q constant	1st order	M A constant	I Q constant
Naming capital letters	26	111	.181	42	290	.366
Naming small letters	46	.365	408	51	.416	466
Giving phonic combinations	.60	584	.622	.55	531	560
Giving letter sounds	49	.435	.449	36	.280	306
Recognizing sounded letters	49	449	472	33	264	295
Writing words	51	427	473	44	.335	398
Mental age	.42			.46		
Intelligence quotient	.42			.38		

*Gates Primary Reading Tests

with small letters and reading words seems to have been less significant than in the kindergarten, while abilities with phonic combinations were quite significant. For that relationship there was no effect from partialing out *MA* and *IQ* as shown in the table by the comparative correlations for phonic combinations with the two reading tests. The first order correlation between word recognition and phonic combinations was .60, with mental age constant it became .584, and with intelligence quotient constant, .622. The first order correlation between paragraph reading and phonic combinations was .55, with mental age constant it became .531, and with intelligence quotient constant, .560.

C. Interpretation

1. *Type of School*

In interpreting the findings of the study the character of the school experiences which were provided the pupils studied must be understood. In a broad sense the school provided informal and vital child-life situations, in which the growth of each pupil in all respects was the center of interest. The teachers' efforts were directed in the main to providing rich and wholesome experiences and guiding the children in their activities.

In the field of reading, emphasis was given primarily to interests in or realization of needs for reading. With that established, help was given the pupils in the mechanics of reading in ways that might well be described as "functional." For example, names were placed on lockers, pinned on clothing, and put elsewhere if they helped the children. Notices were printed on the blackboard. Letters to absent classmates, teachers, or others were written. In the same sense the teachers helped children to learn and use letter forms and sounds. For example, in a situation in which children were trying to read, attention would be called to letters that would help them read the word, such as the first letter sound or some other helpful clue. No formal drills on letters, sounds, or words unrelated to reading needs, however, were given (1-2).

2. *Causal Relationships*

In this sort of informal functional learning, the analysis of the extensive testing carried on with several groups over a period of three years, has indicated that particularly close relationships obtained

between skill in reading and certain other abilities with letter forms and sounds. No other abilities or traits showed *anything* like this close relationship. It is believed that abilities with letters were causal in ability to read for these children. Other evidence besides the relatively high correlations support this belief. Table 9 com-

TABLE 9

CORRELATIONS BETWEEN READING AND LETTER TESTS IN TWO SECOND GRADES

Gates Primary Reading Tests

	Type 1 Word recognition		Type 2 Sentence		Type 3 Paragraph reading	
Grade group	X	D34	X	D34	X	D34
Naming small letters	.37	74	42	.74	42	.69
Phonic combinations	49	64	72	89	.60	89
Giving letter sounds	52	74	50	60	42	53

pares the correlations between certain letter and reading tests in two *second grades*. The *D34* group was taught by the teacher who had had the children in Grade 1, which was the group studied the first year. In both years she made particular effort to use functional methods in helping children master the mechanics of reading. The correlations shown for her second grade were markedly higher than those in the other group, and may well have been due to the more effective way her pupils had learned to use letters in their reading. By the end of the second year this group had been given 14 reading tests and two tests in phonic ability. The average of the 28 correlations between reading and phonic abilities was 863 and the range was from .75 to 93. On objective tests of reading skill this group made average scores which showed achievement normal for their grade placement.

Other evidence that children naturally tend to use letters in beginning reading was found in observing their methods in reading and trying to read. First, tests showed that most kindergarten and Grade 1 children somehow had learned many letters before they learned words. Second, in word tests children constantly and with varied means of attack used letters in an effort to get the words. This was done by frequent audible spelling out of words, by lip movement of the letter sounds or names in the words, by recognizing first letters and sometimes other letters.

Third, one test, the Gates Diagnosis Reading Subtest VIII, 3,

afforded a simple statistical analysis pointing to this functional use of letters. In the test the pupils were required to indicate in a line of six words one word which they had just heard pronounced by the examiner. The test is so constructed that one incorrect word in each line begins with the same letter, and another incorrect word ends with the same letter as does the correct word. Two other incorrect words are either full or partial reversals and the other incorrect one has the same configuration as the correct words, but is made up of different letters. The following tabulation of incorrect responses given by Grade 1 children show the particular use made of initial and final letters.

Type and number of incorrect responses				
Correct initial letters	Correct final letters	Full reversals	Partial reversals	Same configuration
174	78	66	54	72

3. *Application*

The practical application of the findings of this study seems to be careful guidance of children by teachers in making use of letter forms and sounds in mastering the mechanics of reading. Such help would surely not be similar in any way to the once familiar practice of drilling children on the alphabet, syllables, and phonograms, with little, if any, relation of such drill to felt needs and interests. It seems equally probable that such teacher guidance would likewise reject the extreme sort of *sentence* or *word* method of learning to read which is at present found in some schools. This methodology exalts the idea units as the sole approach to learning to read and prohibits any analysis of idea units into letters, and seems to be as far away from the psychological approach natural to children, as the letter drill method was.

The functional approach might be thought of as a combination of the letter and the idea unit methods. Such functional approach would recognize first, that the perception of ideas in written form is aided by perceiving the letters which make up the word forms. Second, it would realize that children as young as kindergarten pupils, if not even younger, grasp that fact with more practical insight than some teachers do. The art of good teaching is shown by the skill with which children are led first, through interest, to secure and to record ideas in written form, and second, through guidance, to

master the forms and sounds of the basic elements of reading as the means of getting and giving ideas. In such an approach the mechanics of reading are always functional in promoting the comprehension of ideas which satisfy reader's needs, in contrast to the approach wherein idea units are the means by which the mechanics of reading are to be mastered.

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"GRATEFULNESS" IN CHILDREN AND YOUNG PEOPLE*

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A. INTRODUCTION

Experimental psychology has not so far dealt very much with the various character traits such as goodness, pity, sincerity, concern, courage, and so on. The first cause of this attitude is to be found in the difficulty of developing a suitable method of research; there is further the complementary action of the fairly usual assertion that character cannot be approached with experimental methods anyhow. We should also mention the inhibition felt by so many scientists in connection with the recent theory of the "total personality." A wrong interpretation of this theory has led to the idea that the study of the various character traits could be neglected. In certain cases there is an additional factor to be mentioned: a number of character traits are said to be very rare and to play such an unimportant part in social as well as in individual life that it does not appear worth while to study them very closely. Gratefulness is supposed to be one of these rare traits, as rare as, for instance, genius or profound love of mankind. The Holy Scriptures already give us an expression of this feeling. Christ heals ten lepers, but only one comes back to thank Him, and the Saviour exclaims: *"Were there not ten cleansed? But where are the nine?"* In all languages there are phrases and proverbs to express the fact that feelings of gratitude are rare and not much developed, and to show at the same time that this particular character trait has no essential importance in social life.

This, however, is not the real case. Anyone who is engaged in the treatment of psychological cases has met with those tragic personal conflicts due to the consciousness of some profound obligation prompted by gratefulness. This particular feeling of duty, which is very marked in certain characters (where one might even speak of an allegiance of gratefulness), may develop into a serious psychic

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burden the weight of which may produce complete psychic collapse or a feeling of permanent unhappiness Thus, it happens quite often that marriage is only maintained on the grounds of a thankfulness which one of the partners feels he must prove to the other, while at the same time he is, generally speaking, unhappy There are other cases where children sacrifice themselves to their parents, without any consideration for the shaping of their own personal lives, out of some misconception of the gratitude they owe to them, a feeling which has been inculcated by their parents or educators. Daughters, more especially, remain spinsters in order to look after their parents as "grateful children" should do, or sons and daughters remain single after the death of one of their parents because they consider it their duty to prove their gratitude to the other parent This often entails the ruin of their psychic life and may also affect that of the person they love Psychiatrists can, on the other hand, observe in a number of cases that the feeling which may come up sometime after the event of having been ungrateful towards a benefactor weighs heavily upon the patient and may, if there is some predisposition towards it, lead to a neurosis Thus, the weight of the obligation towards gratefulness may entail serious damages for the personal life of the individual, while, on the other hand, lack of expected gratitude may lead to disappointment, contempt and even hatred of other people, and spoil the social life of the individual

It therefore appears necessary to analyse the feeling of gratitude in order to secure a more precise knowledge of the psychic characteristics of this feeling, its psychological components, and its mode of expression In doing this we have to give special consideration to the genetic development of this feeling and to a series of questions, such as. Is gratitude an innate feeling? In what circumstances can one speak of conscious gratitude in children? What are the manifestations of this sentiment in the various stages of life? Does it show a specific curve of development? Can any characterological differences be determined? Are there any variations due to difference in sex? Is it a very frequent or, on the contrary, a very rare feeling? Can it be taught?

With a view to obtaining information on all these points, we proceeded to undertake a phenomenological analysis of the feeling of gratefulness and, further, an enquiry covering 2000 schoolchildren aged from 7 to 15 years in the city of Berne

B ANALYSIS OF GRATEFULNESS

The general public considers gratitude to be a reciprocation of some kindness received and therefore interprets it in a purely material and practical sense, from the angle of the psychologist, gratitude may be taken to be a reactive sentiment born in us when we have obtained some kindness or help which we desired This feeling is extremely complex in its nature and we may list the following components

1. Gladness about received assistance, gift or kindness—component of an egoistic nature

2. Benevolence towards the giver, which means a transfer of the joy on him who is actually the originator of the assistance The phrase *"I thank you" is the expression of one's appreciation of the* other's action. Kant has defined gratitude as being "the worship of a person because of the kindness shown to us." We always thank somebody. The action of thanking always in the first place calls special attention to the person who helped In other words, this is a component of a social nature.

3 The desire to render the helper a reciprocal service The joy inspired by the help received is always mixed with an immediate desire to reciprocate The wish develops spontaneously to please the person who has helped, to give him some joy or some gift Whether this desire is realised immediately or only later on depends often on *the technical possibilities of its realisation According to* popular feeling, thanks should not be "empty," that is to say, should not consist of words only but take some concrete form This becomes particularly clear in such phrases as "earn the thanks" or on the contrary of such phrases as "thankless job" Phrases of this kind are even more usual in German and French than in English

This effort to offer some concrete reciprocation is an expression of that law of social relationship which we know more specially as retaliation (*jus talionis*) though it may be not only negative but likewise positive The popular phrase in this case would be *"tit for tat"* Revenge and gratitude are both expressions of the same tendency towards reciprocation Gratefulness tends to a return in a friendly spirit and therefore is again a component of a social nature

4 The feeling of an obligation to reciprocate has given rise to such words and phrases as "to be indebted to someone," "tribute of gratitude," "to be much obliged," and so on The feeling of

gratitude remains in certain cases as long as an obligation has not been fulfilled, and sometimes even *after the effective expression* of gratefulness there remains a relationship binding the person who received to the person who gave. It may be interesting to point out that legislation provides for the prescription of material debts and even of more serious offences, while there is never any reference made to a prescription of the debts of gratitude. It seems that in the case of a psychic obligation created by freely given assistance, there is no possibility of a limitation in time of psychological repayment Gratitude is an eternal obligation and is felt even towards the dead La Rochefoucauld rightly observes that too much haste to repay one's debts of gratitude is, in a way, a sign of ungratefulness Thanks create a relationship between people and develop their feeling of community In other words, gratitude acts as a social cohesive and here again we find a strong component of a social and ethical nature

It thus appears that the feeling of gratitude is a complex one and based mainly on social and ethical elements. It is the social character of gratitude which makes this particular feeling so highly creditable to the popular mind Ungrateful persons are considered as thoroughly objectionable

C Gratefulness Considered from Two Angles

The mere fact that gratitude is a reaction on some service, help, or donation, makes it necessary to consider this character trait from two angles, the angle of the *giver* and that of the *receiver*. It was a serious methodological mistake of characterology that submitted character traits to a one-sided analysis, and did not realise that the majority of character traits are the expression of inter-human relationships, and must therefore be considered from the point of view of *both* persons concerned We are starting out on a new way and have tried to analyse the psychological situation of two persons joined in the common experience of "giving help and receiving help"

In the situation considered both the person who gives and the person who takes are, to a large extent, influenced by their impetus to ascertain themselves ("Geltungsdrang"), but each in a different manner He who gives, experiences through the mere fact of giving, an increase in the consciousness of his power, he is clearly aware of his own superiority over the person requesting his assistance and

this is accompanied by a very strong positive feeling of joy In accordance with the law of conservation of pleasure, he will tend to maintain the memory of such a positive feeling as long as possible *This fact alone would suffice to explain why creditors usually have* a better memory than debtors. It may also serve as an explanation of the desire to receive thanks, since gratefulness recalls kindness and therefore the might or power of the benefactor It is just the reverse that happens in the case of the person on whom the kindness is bestowed The necessity to receive assistance makes that person conscious of his own weakness and incompetence, an experience usually associated with highly unpleasant feelings Hence, the receiver usually tends to forget the benefactor and his kindness as soon as possible It is not, however, wickedness but rather human weakness and the feeling of our inferiority which makes us forget the help received from others This fact is highly important for the correct interpretation of ungratefulness It is also for these reasons that it is necessary to give help in such a way as not to offend the personal feelings and pride of the recipient The phrase "It is not what you give but how you give that matters" was certainly coined by a sensitive recipient

Moreover, this diversity in the attitude of the two partners and in the sentiment they have of their own position and importance, finds an expression in the manner in which each of them tends to judge the help or service given or received

He who gives is apt and ready to value his action very highly and often to over-estimate it, while his partner tends to belittle it Hence the tension between the two partners with regard to the expression of gratefulness The helper unconsciously expects in return a service proportionate to his feelings of self power arising out of the beneficent action, while the indebted person over-rates the value of his own reaction since he is influenced by his tendency to under-estimate the benefit received And again, the grievance felt by the helper when no gratitude is shown is borne of his wounded self assertiveness and is synonymous with a feeling of a diminution of his personality The more self-conscious the helper the more he will be affected by ungratefulness, the stronger his social feelings the more he will suffer from the manifestation of any unsocial action, such as ungratefulness

In the present study we shall only stress the fact that this diversity

of the psychological *experience of both partners* under the same circumstances serves to explain a source of other manifestations of gratitude and ingratitude, such, for instance, as the fact that the same person may on one occasion prove to be grateful and on another ungrateful The sensitiveness towards the way in which the gift or service *is offered is often only significant* of the desire to play the offended party in order to free oneself of the obligation of gratefulness The phrase mentioned above—"It is not what one gives but how one gives and who gives that matters"—is typical, not only in the case of a sensitive recipient, but also in that of a *person who is determinedly ungrateful*

But often an attitude which we consider as ungratefulness is only due to a false interpretation: both partners appreciate the help or gift incorrectly and the significance of gratefulness or of the absence there of it is likewise erroneously interpreted by them Complaints *on account of ungratefulness therefore* originate from insufficient knowledge of the human character

It is an error of the same kind which we commit when we try to deduce anything about the character of an individual from the way in which he expresses or fails to express his feelings of gratitude We must remind ourselves of the fact that there are certain human characters, or rather character structures, where ingratitude may be due to reasons totally different from wickedness or a diminution of the consciousness of their own human value There are people who would as gladly and readily give all they have as they would receive it from others. It may sound a paradox but it is precisely their social qualities and virtues which are the cause of their unsocial attitude, that is, their ingratitude The well-known educator and writer of the early nineteenth century, Jean Paul, aptly recognized this fact and expressed it in the following words "A man will thank all the less for gifts received the readier he is to make such gifts himself, and he who is liberal is seldom grateful " A well-known psychologist, Julius Bahnsen, has drawn attention to a further type of character which, in his opinion, is not capable of gratefulness: "Benevolent and weak characters forget their obligations of thankfulness because they are not capable of being more faithful towards others than towards themselves " We see therefore that *it would not be correct to consider every ungrateful person as wicked.* On the other hand, a grateful person is not necessarily a noble

character, since, as has already been observed by La Rochefoucauld, *man often tends to show gratitude in order to receive further kindness* In other words, thankfulness may be borne of very material reasons and calculation.

Thus, gratitude may be due to quite opposed character traits *There is the thankfulness of the weak person* to whose advantage it is to remain in connection with the giver; there is, on the other hand, the thankfulness of the noble and generous person who interprets the assistance as the expression of the social feelings of the giver

There is the ungratefulness of the so-called wicked person who considers the assistance afforded to him as his due, and there is, on the other hand, the ungratefulness of the active person accustomed to depend entirely on his own initiative and action

All these facts make it apparent that every case of ingratitude must be interpreted separately

D The Various Types of Gratefulness

The theoretical analysis of the feeling of gratitude has already produced certain valuable points of view, but does not give us a complete and exhaustive answer to all the questions defined at the outset with regard to the forms and developments of the feeling of gratitude These replies were found, on the other hand, thanks to enquiries and research work done on children by three methods

The first study of this kind consisted in submitting certain questions to 1059 school children, aged between 7 and 15 years from elementary and secondary schools in the City of Berne These questions had to be answered in writing but were framed in such a way that they did not suggest their aim to the children The first question was *"What is your greatest wish?"* The second *"What would you do for the person who granted you this wish?"*

The results of this enquiry may be summarized as follows

1 *Verbal gratefulness* which manifests itself in such replies as. "I should thank him," "I should show myself grateful," "I should always be grateful," and so forth This kind of gratefulness is equally frequent with children of the various ages (an average of between 30 and 48 per cent of the replies) It is particularly frequent at the age of 15 (72%) This verbal gratefulness must be interpreted in various ways Small children are taught to say "Thank you" for everything they get and they therefore probably only repeat

what they have learned. Children of a more advanced age seem to use this form of verbal gratefulness when they actually do not feel any gratitude, from this there might therefore be drawn the hasty conclusion that the frequency of these answers is proof of the increasing ungratefulness of young people. It should, however, be considered that there were many replies in which a child mentioned as its deepest desire the restoration to health of its mother and said: "I should be thankful from the bottom of my heart and for as long as I lived", therefore, it must be taken that verbal gratefulness is also likely to occur when a child is not able to express its true and deep feelings of gratitude correctly This last interpretation finds confirmation in the fact that that particular type of verbal gratefulness is frequent in the age of puberty where the child is unable to find its own way in its feelings or to express these feelings adequately In other words, two quite different character types—one being completely devoid of sentiment and the other, on the contrary, overwhelmed by it—may express themselves in this form of verbal gratefulness

2 *Concrete gratefulness* through which the child wants to give an object in return for the realisation of its desire In such cases the reply would be. "I should give him a book, a pink bow, a pocket knife," or, where it offers something which seems very valuable to him,—"I should give him a kiss," or the like. Such concrete gratefulness may again be of two kinds.

It may in the first place be only an *exchange* when, for instance, a book is offered for the skis desired by the child, or a watch for the dreamed-of piano. In the case of such exchanges it is interesting to observe that they are nearly always framed from the *viewpoint of the child*: the child gives or offers only what he himself considers to be valuable, such as a teddy bear—his pet toy—for the motor car he would like to receive, or a piece of chocolate for the Red Indian costume and gun Here gratefulness has definitely an egocentric character and is measured by the subjective value attached to the object offered to the giver

In the second place, gratitude may find an expression in the participation offered in the goods received For instance, a child wishes to receive a position as an apprentice in a baker's shop and promises that the person who helped him to attain this objective should receive as a token of gratitude "fresh buns every morning", or the

child who wants a motor car is ready to take the giver on the tours he plans to make with the car once received; or again, the child who wishes for a cottage is prepared to offer lodgings to the gratifier of this wish, and so on. Material gratitude is most frequent with children of 8 years (51%) and most rare with children aged between 12 and 15 years (only 6%).

But even in this tendency to let the partner have a share in his gift or kind action there is an expression of the ego-centrical nature of the child, since it implies the belief that the donor derives pleasure from the objects desired by the child itself. The answer given by a boy aged 8 years and 11 months may be quoted as highly characteristic of this attitude:

> "I woud like a racin car best. So that I coud go to Robinson Crusos iland and to other places. I woud take him [the donor] to Robinson Crusos iland and also to see his famerly."

Here the social component is therefore not clearly distinguished from the ego-centric but, on the contrary, closely related to the latter.

Furthermore, the child does not consider that the person who is in a position to present him with a car is likewise in a position to undertake a beautiful voyage on his own. But it is precisely such naive answers which give us most valuable information about the *social character of the feelings of gratitude*. It is that type of reaction which makes the desire for a community with the donor become obvious and clearly shows the fact that gratitude is the *link*.

From the social point of view, replies in which gratitude finds an expression in the form of a common enjoyment shared by the donor and the recipient are most valuable.

3. The third type of gratitude might be called *connective gratitude*. This term we should like to apply to the tendency to create a spiritual relationship with the donor; an instance of this type of gratitude is to be found in the reply of a child writing: "I would help him and give him pleasure"—"I would make myself agreeable to him"—"I would give him what he wanted himself"—"I would try to do what he himself would not be able to do"—"I would help him in case of need." Certain replies, such as "I would like to serve him"—"I would be obedient"—"I would always obey him," and the like, express devotion and submission, whereas replies, such as "I would love and honour him"—"I would be his friend"—"I

would make him the best of my friends," express the fact that the child feels himself an equal of the donor while receiving the gift or help of the latter This is not a case of *abasement* through assistance, on the contrary, the assistance or gift is felt to be something for which the recipient is in a position to *offer something in return (love, faithfulness, friendship)* Connective gratitude becomes more frequent from the 11th year and for the group aged 12 it occurs in 60 per cent of all cases. It is the liberation of the child from the ego-centric point of view. In other words, with the growing mental development of the child which entails the development of his social understanding, *the feelings of gratitude find a superior form of expression* However, the fact that a number of children adopt that particular form of gratefulness at the age of only seven is a proof that genuine sentiments of gratitude may manifest themselves even at such a tender age.

It is characteristic of the social feelings of young people that in *a number of cases gratitude finds an expression in a feeling of active* kindness towards humanity at large and not only towards the donor Thus, a girl of 15 wrote "If I had a car I would sometimes take my friends for a drive If I saw, for instance, old people who were not able to walk easily I would take them along also I would do all the shopping for our neighbours and I would do many other useful *things* if I had a car" *This gratifying social attitude* sometimes occurs in quite young children, and more especially in girls Thus, a little girl of 10 wrote

> "My gratest wish is to have lots of munie Then I woud bild a hospitl with a big garden I woud take into my hospital many little chilren who had infantyl paralersies. But I woud also take in men and gurls. They woud push the chilren in prams and the men who woud be dokters woud have to cure the chilren."

Likewise a little girl of 11 wrote "I would be very grateful to him and if he had children and the children were ill I would heal them "

4 A special type of *gratitude consists in the tendency* of the child or youth to reciprocate for the realisation of his wish by an action which would be in some way helpful for the object or the situation desired, or would promote their personal development. We might call this type *"finalistic"* gratefulness. It is usually the *sequence of a desire connected* with the future activities of the child.

For instance, a girl of 14 who expressed the wish to get a good job at a later stage wrote "I would always be punctual and honest in my work" A boy of 14 wants to go to high school and promises to show his gratitude to his protector in the following words "I would always try to get good marks" A girl of 14 declares:

> "I wish I could become an honest, frank and kind person If someone who was fond of me could make me become like that I would show myself thankful and would reward him for all his trouble in trying to be very good"

With respect to the qualitative relationship between the wish and the gratitude, it is to be observed that with a concrete gift, such as clothes, toys, books, a motor car, we do not in every case find material gratefulness and that, on the other hand, for the fulfilment of wishes of an abstract nature, such as health—the children's or their parents, or the desire to go to high school, it is not always a connective gratitude which is expressed On the contrary, it is precisely for the fulfilment of wishes deeply rooted into the child's soul, such as to be cured of stammering, of epileptic fits, or of some definite physical pain, that children aged between 13 and 15 years frequently manifest verbal or concrete gratefulness, whereas their gratitude takes a higher form in the case of the realisation of some concrete wish, that is, for the gift of some object From this we may infer that the form taken by a child's gratitude rather depends on the individuality of that child and that every child has its own way of expressing its thanks, whether in words, deeds, feelings or actions

E Gratefulness and Character

Those four kinds of gratitude, therefore, indicate *four different character types*. Moreover, we can detect a great number of characterological differences in the manifestations of concrete gratefulness There are children who would like to make presents in return and give things which belong to themselves or of which they can dispose immediately—a bangle, a teddy bear, a book, others want to give away things which they neither possess nor can possess at the moment· for instance—"I would give my heritage," or "the whole of my fortune" The first type denotes children who are more sensible, positive and realistic in their promises The others have more impetus

and imagination but are unreliable and their promises are only an empty phrase

Another important characterological difference appears in the manifestations of concrete gratitude, as a token of their gratitude certain children offer *objects*, while others want to *do* something They want to sew or knit, read aloud to the donor or do his shopping, and so forth These are the children of a motor type who want to take an active part in the framing of every situation and always tend to find an outlet for their efficiency We might label them the *"efficiency type,"* while the first group might be called the *"object type"* The efficiency type again may appear under various aspects In one case the donor is the centre of interest and any activity considered is to his benefit the child wants to work in the garden of the donor or help him with housework or shopping, and so on Other children want to be active but not in connection with the grown-up, the action is related to their own interests or to those of the object given or promised to them, they intend to look after the flowers they receive or to be good pupils when they get to high school, and the like Sometimes such promises sound rather egoistic since they are manifestations of an impulse to achieve *personal success or pleasure*. Obviously this attitude is characteristic of egocentric types

Further characterological differences become apparent if we try to establish a quantitative and qualitative relationship between the four forms of gratitude and their various aspects, on the one hand, and the wishes of the child on the other We may distinguish between *parsimonious* and *excessive* gratitude by ascertaining the degree of proportionality between the child's thankfulness and the importance of the desire (it will be remembered that in every case it was the greatest wish of the child which was to be fulfilled) Thus, if the child writes that for the car he wants so keenly he would be ready to give the donor *something sometime,* we might consider this to be parsimonious thankfulness, a sign of a calculating and very positive nature (or even avarice) On the contrary, if a child is ready to "serve his whole life" in exchange for some toy, or if the child writes, "I would give him all my kindness if I could," this is an excessive form of thankfulness characteristic of an impulsive, imaginative, and generous nature

The method of enquiry which we have adopted might be open

to the criticism that it did in itself provoke the manifestations of gratitude. Therefore we applied another method in order to ascertain spontaneous feelings of gratitude. 530 children, boys and girls, aged between 10 and 15 years were read a story which may be summarised as follows:

> "A rich peasant fell into the water, another one saved him, but in hoisting him out injured him on the forehead with his pole. The rich peasant took an action against the one who saved him on the grounds of this injury. What should the Court's decision be?"

The children were to reply to this question according to their own ideas. As a result it was found that only 14.71 per cent of the children understood that there was here a patent ungratefulness on the part of the rich peasant and labelled the attitude of the latter with the word ungratefulness. All the other children declared that it was unfairness. Very similar results were achieved in the case of 41 apprentices of the Railway Shops in Basle who were asked to give a written account of the same story. Only 14.5 per cent in this group recognized in the situation described an action which called for gratitude. These results seem to indicate that children and young people are not clearly conscious of things for which one should feel thankful. This alone is a sufficient proof of the necessity for parents, teachers, and educators to discuss problems and situations of thankfulness with children and in so doing to help children towards the immediate experience of mutual social obligations and relationships.

On the other hand, it appears from the enquiry mentioned above that children possess a strong tendency towards gratefulness provided they clearly understand that a given situation calls for gratefulness. It would almost appear, in view of the so frequent ungratefulness of grown-ups which is a cause of general complaint, that this feeling was in later years subject to a regression. It is considered that gratefulness is stronger in children and young people because they are in greater need of assistance and protection and that this feeling is therefore a manifestation characteristic of a certain age. But it is also possible that this feeling subsides because it has not developed properly.

F EDUCATION AND GRATEFULNESS

What can be done in order to maintain and even strengthen the feelings of gratitude? The enquiry which we pursued has in itself given us many useful hints in this respect In the first place, it is necessary to make the children *familiar* with the nature of gratefulness and more especially to explain to them the social nature of this feeling So far gratefulness has usually been represented either as a *form of politeness* or as an *obligation*. Both these representations tend to make gratefulness unpleasant to the child What is, on the contrary, necessary is to point to the *community* created and strengthened through gratefulness and diminished or even destroyed by ungratefulness In connection with stories such as the one of the ungrateful peasant mentioned above, one should discuss "situations of gratefulness" and point to the correct social attitude The deeper analysis of such situations may bring up a consideration of the various types of expression of gratefulness and thereby help towards a better understanding of the manifestation of other people's sentiments Particular attention should be devoted to the description of the *ways and means towards community through gratefulness* Giving and taking should be represented as a social fact which creates a closer connection and link between human beings

To ensure the effectiveness of such explanations one should speak frankly of all the facts which help towards the absence of gratefulness, such as for instance, written law which provides for the punishment for the non-payment of even a small debt but makes no provision for retaliation upon the grossest form of ungratefulness. However, this should not be represented as a deficiency in common law, but it should be mentioned that it would have been rather shameful if it had been thought necessary to establish a definite regulation regarding such a self-evident attitude. Some mention should moreover be made of the weaknesses of human nature, such as vanity, the desire to assert oneself, and so forth, which make men tend to underestimate noble actions and are one of the fundamental reasons for the so-called "bad memory" of the debtor It should be pointed out that every recipient has the obligation to assist his own possibly deficient memory with some adequate measures.

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A COMPARATIVE STUDY OF MENTAL DEVELOPMENT IN INFANCY*[1]

Lenin Institute for the Post Graduate Training of Physicians, Kazan, U S S R, and the Institute of Child Welfare of the University of California

Belle Dubnoff

The study reported here deals with children from two distinctly different milieus in the city of Kazan (Tatar republic, U S S R) One group was composed of infants from the nurseries or crèches maintained in connection with manufacturing establishments in different parts of the city. These children are brought to the crèches when the mother begins work, and taken home when she finishes. During the factory day the children in the crèches have a regular, carefully observed regime with set times for nourishment, recreation, and rest. The younger infants are supplied with a variety of toys, which are suspended over their cribs with the purpose of stimulating manipulative play and motor coordination, at an early age the children are taught to feed themselves and are encouraged in locomotor activity and in habits of self care.

The second group of infants were reared entirely in private homes. They were tested at various district public health clinics when brought by the mother for a medical examination Clinics were selected in different neighborhoods so that the sampling would be as nearly comparable as possible to that observed in the crèches. The two groups differ, however, not merely in regime but also in the fact that while the crèche group is composed entirely of workers' children, the home group covers a wider socio-economic spread and includes children of unskilled workers, technicians, and white collar workers

As originally proposed by Dr Harold E Jones, it was hoped that it would be possible to follow through the same group of

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[1]This study was carried out at the suggestion and with the help of Dr Harold E Jones, Director of the Institute of Child Wefare The writer is also indebted to Dr Nancy Bayley for training in test procedures, and to Professor E M Lepsky of Kazan, for providing necessary facilities and offering valuable advice and guidance

children, retesting them at monthly intervals. After working for several months, it was found that this method could not be applied systematically, due to the difficulty of obtaining the same children every month. A compromise method was therefore decided upon whereby whenever possible the same child was retested, and in this manner several individual growth curves were obtained. Many subjects, however, were tested only once.

Altogether there were 489 subjects of whom 207 were children reared in the crèches, and 282 were children reared at home. To these 489 subjects 936 tests were given in all.

The Test Situation

The subjects were tested in two experimental situations, determined by the group to which they belonged. The examiner visited each crèche monthly and tested all the available infants. A table was set up in the quietest part of the crèche and the test administered with the help of a nurse. In the clinics the tests were administered in a separate room with the assistance of the mother.

During the first months the infant was tested lying down in a crib. At about the fourth month some of the test items were given with the child sitting in the mother's lap, and from five to six months of age all the tests were given to the child sitting up at the table on the mother's or nurse's lap. The test used was *The California First Year Mental Scale* (1). For each case a "basal" was attained (this is the point at and preceding which the child passed every item), testing was progressively continued until uniform failure for the later items was registered.

Comparison of Kazan and California Infants

Table 1 and Figure 1 present a comparison between the total Kazan sample and infants tested by Bayley (2) at the Institute of Child Welfare in Berkeley, California. The Berkeley sample came from homes tending to be slightly above the average of that community in socio-economic status.

The Kazan sample shows markedly superior scores during the first three months. From the fourth to the eighth month the Kazan means drop to a point approximately one sigma higher than the Berkeley means. In the tenth month the two groups are equivalent

TABLE 1

CUMULATIVE POINT SCORES—MEANS, MEDIANS, SIGMAS, CALIFORNIA STUDY AND KAZAN STUDY

Months	No of cases		Mean		Median		S D	
	Calif	Kazan	Calif	Kazan	Calif	Kazan	Calif	Kazan
1	52	55	4 58	10 98	4 54	9 85	1 50	3 5
2	58	99	11 60	16 17	11 65	15 17	2 13	3 35
3	61	127	18 48	23 12	18 14	23 029	3 47	3 86
4	58	123	28 76	31 60	29 07	30 66	4 79	5 27
5	58	116	38 31	44 74	39 00	45 83	5 94	9 41
6	57	105	48 93	57 5	51 00	59 37	8 92	10 88
7	52	82	60 90	71 69	61 50	72 08	7 62	7 29
8	56	66	70 98	77 14	72 25	76 18	6 75	5 03
9	53	51	78 27	81 30	78 50	81 58	5 52	4 35
10	56	52	85 77	85 38	86 50	84 62	4 78	5 08
11	52	19	91 04	87 84	91 75	88 5	4 10	5 06

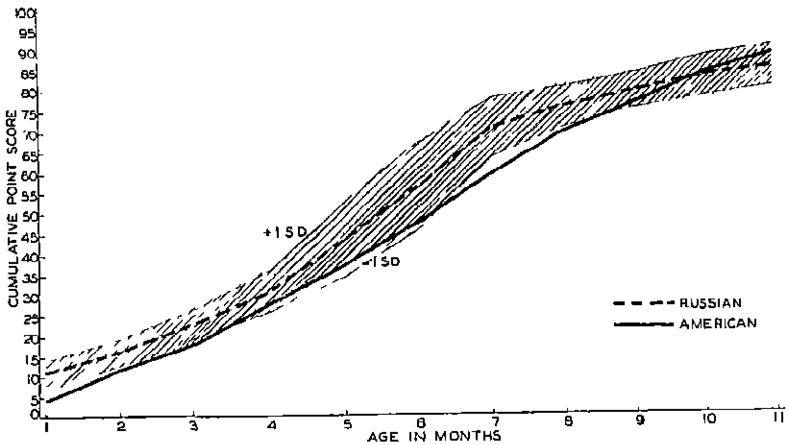

FIGURE 1

COMPARISON OF RUSSIAN AND AMERICAN CHILDREN, USING THE CALIFORNIA INFANT MENTAL SCALE

in score The superiority of the Kazan group ranges from two to four weeks of mental age during the first nine months

It should be noted that due to factors in the construction of the test, and the shifting nature of the functions measured at these

early ages, the standard deviation of the California group shows an increase from the first to the sixth month, followed by a decrease. This is paralleled by the Kazan group, although the latter manifests a slightly higher variability, caused probably by the fact that the age range represented at each age was slightly greater (i e , it was not possible to test the Kazan children as close to their month birthdays as had been done in the case of the California study)

Before attempting an interpretation of the differences found, some mention should be made of the apparent environmental advantages enjoyed by the California children Belonging for the most part to small families, favored with regard to diet, sunlight, and the availability of expert knowledge, their regime presents a marked contrast to that of the children of Kazan Due to the cold winters, the Kazan child is heavily clothed, and often wrapped in blankets which prevent freedom of movement Except for about two months of the year, he is never exposed to the sunlight. From an early age the infants are accustomed to the use of pacifiers. When they cry, they are picked up and rocked in the arms of the mother, and very often the breast is given in order to quiet the child, without regard to feeding schedules. Rickets is prevalent The level of education of the parents is very markedly lower than that of the California sample (average years of schooling of the California group is 13.4).

The relatively precocious performance of the Kazan infants, in spite of environmental handicaps, suggests an interesting problem in natio racial differences. The hypothesis may be offered that early precocity is related to an earlier maturity and perhaps a lower average intelligence level at maturity. Some support of this can of course be found in phylogenetic comparisons, and also in a few studies which suggest, within a given group, a possible negative relationship between children's scores and later performance, or between children's scores and measures of social or educational status of the parents (2, 3) At the present time, however, we have no satisfactory appraisal of the adult intelligence level of the Kazan population; it appears necessary to assume some genetic differences in accounting for the present results, but no assumptions can be made as to the manifestation of such differences, either in the same or in a reversed direction, at the adult level

Race and Sex Comparisons within the Russian Group

Of the 489 subjects, 160 were of Tatar extraction, distributed in the crèches and homes in about the same proportion as the Russian children. Comparisons were made at the third and the sixth month, but with no significant differences appearing; the distributions for the two racial groups were nearly identical. No sex differences in cumulative point scores were found in this sample.

Comparison of Children from Home and Crèche

Table 2 presents comparative data for the home and crèche chil-

TABLE 2

Cumulative Point Scores—Means, Medians, Sigmas, Crèche and Home Children

Months	No. of cases		Mean		Median		S.D.	
	Crèche	Home	Crèche	Home	Crèche	Home	Crèche	Home
2.5-3.4	57	70	22.28	23.04	21.62	23.1	3.53	3.92
3.5-4.4	73	50	30.6	33.00	30.18	32.50	4.80	5.86
4.5-5.4	65	51	43.00	48.00	39.85	47.75	9.30	8.77
5.5-6.4	56	49	57.30	58.80	58.33	59.77	11.69	8.57
6.5-7.4	50	32	71.48	70.53	71.00	71.00	7.27	7.86
7.5-8.4	38	28	77.54	78.34	78.40	79.00	5.34	5.00
8.5-9.4	24	27	80.92	81.22	81.42	81.25	4.46	4.05
9.5-10.4	27	25	84.30	86.28	86.2	86.50	6.59	4.56

dren, showing at nearly every month a slight tendency for the home sample to show higher means. The differences are too small to be reliable. In terms of medians, the two groups are closely equivalent after six months. It might be thought that whatever environmental advantages are present in nursery schools would also be found, at this earlier age, in crèches. Regime is more regularized than in private homes, and we may infer on the average greater attention to the systematic stimulation of general activity as well as to the schedule of rest and nourishment. One point of some interest emerges in the comparison of SD's of the two groups. In view of the greater socio-economic spread of the home group, and also the greater diversity of regimes in this group, it might be expected that environmental factors, if important in mental development during the first year, would be reflected in a higher variability of scores for the home group. It is, however, apparent that the two samples have closely similar SD's with no systematic difference between them.

Relationship of Earnings to Cumulative Point Scores

For the purpose of this analysis only the home group is used. Correlations with father's earnings were made for three months—the third, the sixth, and the tenth. For the third month a correlation of $.27 \pm .07$ was obtained, for the sixth month a correlation of $.44 \pm .07$, and for the tenth month $.44 \pm .07$.

These positive correlations deserve some attention, in view of Bayley's finding of a negative correlation between test score and socio-economic status in the early months of infancy. It might be supposed that in the Soviet Union the attempted equalization of medical care and other environmental factors which are of potential importance in child development would tend to hold down any environmental correlations. On the other hand, it is the impression of the writer that because of greater opportunities for individual advancement, income is in the Soviet Union a better measure of individual differences and of ability than in other countries. It is possible that the positive correlation with economic status, found in this sample at a considerably earlier age than in studies in the United States, reflects not an environmental factor in child development but an efficient selective factor in the economic system, and a parent-child correlation based chiefly on genetic factors in a population of very wide variability.

Summary

1. The California First Year Mental Scale was given to 489 infants, in Kazan, U.S.S.R. Of these cases, 207 were from crèches (factory nurseries), and 282 from homes. In all, 936 tests were given. The ages ranged from one to eleven months.

2. The Kazan sample showed a marked superiority to the California sample in the early months, the differences decreased until 10 months, when substantially the same means were found for the two groups.

3. There is no difference between Tatar and Russian Infants as measured by these tests.

4. No sex differences were found in this study.

5. There is no tendency for crèche children to obtain higher scores than those raised at home, although environmental advantages may be postulated for those in crèches.

6. The crèche and home groups have closely standard deviations

in mental test performance, despite the fact that the home groups presented a greater diversity of regimes

7 In the home group a positive relationship occurs between the scores and family earnings, this is interpreted in terms of genetic rather than primarily in terms of environmental factors

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VICARIOUS TRIAL AND ERROR AT A POINT OF CHOICE: I. A GENERAL SURVEY OF ITS RELATION TO LEARNING EFFICIENCY*

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Numerous experimenters have reported that rats at a point of choice often hesitate and alternately face the alleys ahead of them For a number of years we have recorded the occurrences of such behavior in our discrimination experiments. This article will present some facts regarding the relation of this choosing behavior to learning efficiency Its aim is to offer a survey of diverse aspects of the problem rather than exhaustive studies of specific aspects.

It was Tolman who first suggested in 1926 that such choosing behavior might be related to learning efficiency. Describing the behavior of white rats in mazes he said

> "I have seen at certain stages in their learning very patent instances of such hesitation at a choice point between two alleys The rat stops and wiggles its nose from side to side and then finally chooses And I have noted further that in such cases he usually chooses the correct one more often than when he does not hesitate" (5, p 367)

Later, in 1932, Tolman devoted a whole chapter in his *Purposive Behavior in Animals and Man* to this problem. In his characteristic way he then said.

> "This opens up the possibility of a concrete investigation which someone should carry out The fact of sudden drops in the learning curve is of course familiar . But what we are seeking, now, is not this mere fact of sudden drops, but rather a correlation between the appearance of such drops and the appearance of just preceding 'runnings back-and-forth' For if this sort of correlation could be demonstrated, it would be direct evidence for our definition of consciousness Will someone please try it?" (6, p 216)

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Finally, in his President's Address in 1937 (7), Tolman answered his own plea by showing some graphs demonstrating the correlation he had predicted.

Beginning in 1929, we have made systematic[1] records of the choosing behavior of rats in discrimination boxes at the Colorado Laboratory. Our first published reference to such observations appeared in 1931 (4, p. 204), just after the completion of the manuscript of Tolman's book containing his urgent plea. In a later publication (2, p. 89) we used the term "vicarious trial and error", abbreviated *VTE*, to denote this behavior. Here we shall continue to use this term and its abbreviation.

Although our records on *VTE* are a by-product of experiments designed for quite different purposes, we have accumulated enough of them under different conditions to use them now as the basis for a preliminary quantitative analysis of the relationships between the frequency of *VTE* and variations in learning efficiency.

The Experimental Situations

In the records taken from our experiment on tone sensitivity the apparatus was a *Y*-shaped discrimination box (4, p. 197). In one situation the discriminanda were a tone-filled alley and a relatively silent one. In another they were silence for a right turn, and a diffuse sound for a left turn. This situation turned out to be especially significant as far as an understanding of the function of *VTE* is concerned.

In the records taken from our experiments on the function of punishment the apparatus was a T-shaped discrimination box (1, p. 268). In one situation (3) the rats were shocked for wrong responses, in another for right responses, and in a third they received no shock at all. In these three situations the rats were hunger-food motivated, while in the fourth (2), their only motivation was escape from shock.

All animals were about seven weeks old at the beginning of the

[1]I want to express my appreciation to my conscientious coworkers who have helped to gather the material on which this report is based: Dr. Evelyn Gentry, F. Milford Fletcher, Arthur H. Bernstone, and Lee R. Richards.

experiments The usual task was 10 trials per day except for the first four days when they were given only five trials per day.

Description of Vicarious Trial and Error Behavior

Our criterion for recording *VTE* behavior in any one trial was a facing into one alley before the other one, whether right or wrong, was entered This alternation in facing the two choice alleys is accomplished in various ways by white rats The most common way is for the rat to stop at a mid-point between the alleys and turn his head first towards one and then towards the other alley But he may also approach the entrance to the alley and orient his whole body towards it and then turn and approach the other alley in a similar way If electric shock is used as punishment he may stretch a large part of his body over the electric grid without touching it. Sometimes the movements may even be more extensive. After facing an alley he may run back to the starting point and then run to the other grid

Recently we also started to keep a record of the distance which a rat penetrated into the wrong alley before he turned back. For this purpose we marked off equal distances by vertical lines on the walls of the alleys so that this preliminary stage to *VTE*, if it is such, can also be treated quantitatively

The Results

1 *The Effect of Shock after the Point of Choice upon the Frequency of VTE* Three groups of rats were trained in the T-shaped discrimination box to go to a white stimulus patch, 4 in square, and avoid the alley with a dark patch One group received no shock, another was shocked for wrong responses, and a third one was shocked for right responses The frequencies of *VTE* for the first 100 trials are given in Table 1

In general, there is a rise in the frequency of *VTE* in the beginning and then a decline for all rats. But the groups differ in an interesting way The shock groups reach their peak sooner than the no-shock group, and the total frequency of *VTE* is higher for the shock groups than for the no-shock group. These observations are paralleled by the learning efficiencies of the groups The shock groups were considerably better than the no-shock group If we further compare the two shock groups on the basis of the first 50

TABLE 1

THE FREQUENCIES OF *VTE* IN A BLACK-WHITE DISCRIMINATION HABIT
(Collaborators A H Bernstone and L R Richards)

Trials	No-shock	Groups (of 25 rats each) Shock-wrong	Shock-right
1–10	88	109	109
20	71	151	105
30	75	129	145
40	75	142	145
50	116	133	132
60	88	107	118
70	98	113	116
80	101	109	116
90	70	99	120
100	82	89	111
Totals	864	1183	1217
Errors per rat	23.2	11.3	17.0
Trials to learn the habit	107.2	34.8	45.2

trials (during which they acquired the habit) we find that the shock-wrong group had a *VTE* frequency of 664 and an error total of 250, while the corresponding values for the shock-right group were 636 and 395 respectively.

This inverse relation seems to be fundamental and can probably be expressed in a generalized statement as follows: Given the same discriminanda and the same apparatus, any condition, such as shock after the point of choice, which tends to increase the frequency of *VTE* also tends to increase learning efficiency

It should be noted that after the first 50 trials the shock-right group has a consistently higher frequency of *VTE* than the shock-wrong group This difference is probably due to the continued occurrence of shock in the shock-right situation as compared with its disappearance in the shock-wrong situation

2. *VTE in Relation to the Mastery of a Habit* Adopting "two consecutive series of ten errorless trials" as a criterion of learning for the three groups just described we get the comparisons presented in Table 2. Any criterion of learning is an arbitrary measure. And yet this table shows that a specific psychological event seems to correspond to the criterion we happened to choose: The frequencies of *VTE* in the two series immediately preceding the criterion and dur-

TABLE 2

VTE Before and After the Criterion of Learning in a Black-White Discrimination Habit

(Collaborators: A H Bernstone and L R Richards)

Trials	Groups (of 25 rats each)		
	No-shock	Shock-wrong	Shock-right
First 10	76	94	96
Last 10 in which errors occurred	103	134	123
First 10 without errors	81	125	127
Second 10 without errors	75	121	117
Succeeding 10 without errors		104	109

The third and fourth rows represent the criterion of learning Two successive series of ten errorless trials

ing the two series of the criterion are higher than those further removed

The conclusion suggests itself that the frequency of *VTE* attains its peak during that phase of learning in which the mastery of the habit is established.

3 *VTE in Relation to the Automatization of a Habit* If rats learn a black-white discrimination habit in a T-shaped apparatus the frequency of their *VTE* behavior decreases after they have mastered the habit, as shown in Tables 1 and 2 If, however, they learn such a habit in a Y-shaped apparatus, their *VTE* behavior disappears altogether after they have mastered the habit, that is, after they have started to make consistently correct responses The reason for this difference seems obvious. In a Y-shaped box the animal can see both stimulus patches while approaching the point of choice; here, the act of choosing does not necessarily require that the rat stop and look first into one alley and then in the other, as is the case in the T-shaped box

In Table 3 are given the detailed records of Rats 1 and 2 which learned a black-white discrimination in a Y-shaped box. Shock was given for wrong responses. As soon as errors disappear, that is, as soon as the habit is automatized, *VTE* also tends to disappear After trial 120 there were no more errors and practically no more *VTE*'s

In a tone experiment (4) rats were trained to respond to auditory cues in the same Y-shaped box with shock for wrong responses.

TABLE 3
INDIVIDUAL DIFFERENCES IN *VTE* AND ERRORS PER SERIES OF TEN TRIALS
(Collaborator: Dr. Evelyn Gentry)

Trials	Visual discrimination Rat 1 Errors	Rat 1 *VTE*	Rat 2 Errors	Rat 2 *VTE*	Diffuse sound and silence Rat 3 Errors	Rat 3 *VTE*	Rat 4 Errors	Rat 4 *VTE*	Sound-filled and silent alleys Rat 5 Errors	Rat 5 *VTE*	Rat 6 Errors	Rat 6 *VTE*
1–10	4	6	5	7	6	7	4	3	4	2	6	1
20	2	7	2	8	5	8	5	3	4	3	5	7
30	0	9	0	9	4	8	2	0	6	6	4	3
40	1	5	0	5	3	10	6	0	4	0	6	0
50	1	10	1	9	2	9	7	1	4	5	4	0
60	0	3	0	6	3	10	2	0	4	8	8	3
70	0	3	0	8	2	10	2	0	4	4	3	4
80	0	4	2	9	3	9	5	2	3	2	2	3
90	2	9	0	8	6	10	6	0	6	5	5	5
100	0	8	2	10	4	9	7	0	5	4	4	3
110	0	6	0	6	4	7	6	3	5	8	6	3
120	0	5	0	10	1	10	1	3	5	4	4	2
130	0	0	0	2	3	10	4	0	5	8	2	0
140	0	0	0	0	3	10	3	3	4	8	5	4
150	0	0	0	0	0	9	2	1	4	8	4	2
160	0	0	0	0	2	10	3	5	5	8	4	0
170	0	0	0	0	0	10	0	10	3	9	5	0
180	0	1	0	0	4	8	1	9	0	7	7	2
190	0	0	0	0	1	10	1	10	2	6	5	0
200	0	0	0	0	2	10	0	10	2	9	6	4
210					2	10	0	10	1	9	5	2
220					2	7	2	10	0	9	4	3
230					2	9	1	10			6	2
240					0	10	1	9				
250					1	8	0	10				
260					2	10	0	8				
270					3	8						
280					1	10						
290					3	9						
300					3	10						

The apparatus for these three conditions was a Y-shaped discrimination box.

Although the training period was much longer than in the visual experiment, no rat made a record in which errors were entirely absent, nor was there a tendency for *VTE* to disappear Rat 3 in Table 3 presents an example of the continued occurrence of errors and *VTE*. Only the first part of the rat's record is given here, the character of the record does not change for the next 300 trials.

We might summarize these results as follows In an easy learning situation (where errors quickly disappear) *VTE* tends to disappear after the habit has been mastered; in a difficult situation (where errors persist) *VTE* seems to persist indefinitely

4 *Individual Differences.* If *VTE* be considered a manifestation of the "attentivity" of an animal, one may speak of attentive and inattentive animals with reference to high and low frequencies of *VTE*

Rat 6 in Table 3 has the record of an "inattentive" rat learning to respond to auditory cues in a Y-shaped box with shock for wrong responses Neither *VTE* nor correct responses attain a high frequency The record of Rat 5 is that of an "attentive" rat in the same situation. Here *VTE* and learning efficiency rise together

In No 4 of Table 3 we have the record of a rat which shifted after Trial 150 from a period of "inattentiveness" to one of "attentiveness" with a corresponding transition from inefficiency to efficiency In Rat 3 we have a consistently good learner in the same discrimination box

Whether or not we want to call variations in *VTE* changes in the "attentiveness" of an animal, the factual relations in these cases are these. The higher the frequency of *VTE*, the greater the learning efficiency of an animal.

Similar relations were observed in two groups of rats learning a black-white discrimination in the T-shaped box with escape from shock as the only motivation (2) One group of 12 animals was hungry, the other group of 13 animals was satiated while running through the box, which never contained food. The frequencies of *VTE* and errors for the two groups showed the following averages per rat per 100 trials (Collaborator. F M Fletcher)

	VTE	Errors
hungry rats	10 5	19 8
satiated rats	19 0	12 8

Here too we have a record of the inverse relation between errors and *VTE*, or the direct relation between learning efficiency and *VTE*.

5 *The Relation of VTE to the Discriminanda.* When we first started to make systematic observations on *VTE* behavior we supposed that its chief function was to enable the animal to compare the cues to be discriminated, and that without discriminable cues present in the choice alleys there would be only a sporadic occurrence of *VTE* This view turned out to be erroneous.

In the tone experiment already referred to (4) 11 rats were trained to respond to diffuse stimuli. The source of the sound was suspended 1 *m* above the point of choice and the animals learned to turn into the left alley when the stimulus was sounded, and into the right alley when there was silence In the case of all rats *VTE* occurred and,—what was still more surprising,—*there was the same relationship between frequency of VTE and learning efficiency as in the case of a visual discrimination* Rats 3 and 4 in Table 3 were trained with diffuse auditory stimuli, a tone and a buzzer respectively. Their records show the same relation between errors and *VTE* as rats trained with visual stimuli as discriminanda

While one must admit that the comparison of cues is probably a function of *VTE* in the case of visual stimuli present in the choice alleys, it seems possible that *VTE* also has some other function, the effect of which is likewise a facilitation of learning Otherwise, how could *VTE* and learning efficiency parallel each other in a case where there are no discriminable cues in the choice alleys?

It is pure speculation to suggest that *VTE* in this case has the function of aiding the re-instatement of the after-effects of past responses to the discriminanda of the situation And yet, such an explanation seems plausible if one grants that the after-effect of a response determines the next response when the same situation recurs.

6 *VTE and the Shortening of Entry into the Wrong Alley.* When a rat enters a wrong alley for the first time he runs to the end of it before he turns around and retraces it At later trials he often turns around before he has reached the end. The question arises: Is there a progressive shortening of the distance which is traversed in the wrong alley, and is there a relation between this shortening of the wrong distance and the frequency of *VTE*?

For the sake of quantitative records, the walls of the choice alleys

in the ┬-shaped discrimination box were marked by vertical pencil lines so that the distance from the beginning of an alley to various points could be read off in fractions of its total length In the records below, in Table 4, a value of 1.0 means the total length of the alley, 0 6 means 6/10 of the length, and so on The point on the wall just opposite a rat's nose before he turned around was taken as the end point of the distance he penetrated into the alley. Measurements of this sort are necessarily rather rough The records for three groups of 25 animals are given in Table 4 The animals are

TABLE 4

DISTANCES TRAVERSED IN THE WRONG ALLEY DURING ACQUISITION OF A BLACK-WHITE DISCRIMINATION

(Collaborators A H. Bernstone and L R Richards)

Trials	Groups (of 25 rats each) No-shock	Shock-wrong	Shock-right
1–10	1 0	6	1 0
20	1 0	4	1 0
30	8	.4	9
40	.6	2	1 0
50	.7	2	9
60	5	2	1 0
70	6	3	1 0
80	6	3	1 0
90	6	5	1 0
100	7	4	1 0

The measurements are in terms of the length of an alley as the unit Each value represents the average per rat per error 1 0 means penetration to the end of the wrong alley, 5 means turning around after half the alley was traversed, etc.

the same as those whose frequencies of *VTE* are given in Table 1.

In both, the shock-wrong and no-shock groups, there is a gradual decline of the distance the rats penetrated into the wrong alley. The decline is more rapid in the shock-wrong than in the no-shock group, so that one might be tempted to assume, comparing Tables 1 and 4, that there is an inverse relation between the frequency of *VTE* and the distance traversed in the wrong alley. However, this would be a false assumption as shown by the record of the shock-right group Here the rats persisted in penetrating the wrong alley to the very end, although the frequency of *VTE* in this group is slightly higher than that in the shock-wrong group Evidently, *VTE* is not simply a vestige of the turning around in the wrong alley

Discussion

The facts here presented show a direct relationship between *VTE* and learning efficiency To be sure, all we have observed is a certain parallelism The frequency of *VTE* rises at the same time that learning efficiency rises, and when the habit is learned there is a tendency for *VTE* to diminish and even to drop out altogether if the situation is favorable We have not demonstrated a causal relationship between the two But the assumption is rather obvious that the choosing behavior of the rat, the turning of his head first this way and then that way, is a means to facilitate learning

The behavior displayed by the animal is very much like that of trial and error, that is, like the testing out of the choice possibilities, except that it is more restricted in scope The two alleys are not actually entered in succession, but the rat points his nose in the direction of one alley before he enters the other one It is this similarity which has prompted us to call the choosing behavior "vicarious trial and error"

The alley finally entered is not always the correct one But the records show—in agreement with Tolman's remark quoted above—that the more frequently *VTE* occurs, the more frequently the right alley is entered (Table 1). It is this relationship which makes the assumption so plausible that *VTE* is a means by which learning is facilitated

I am tempted to go a step beyond this assumption. Granted that it is correct, we would have here a mode of behavior lying midway between gross trial and error behavior and symbolic thinking. In *VTE* we would have a rudimentary trial and error behavior. The animal still "goes through the motions," but only to a limited extent Behavior appears here as if it were contracted within a narrower—perhaps a gestural—sphere than in the case of gross trial and error And in symbolic behavior the contraction would be a still greater one, namely, within the organism itself. The behavioristic account of thinking would lend theoretical support to such an interpretation of *VTE* as a primitive level of thinking

This position is similar to Tolman's who supposes

> "that in the higher animals, and perhaps even in rats, there is an ability to embark not only upon an actual running-

> back-and-forth but also upon mere surrogates (for such overt behavior), mere behavior feints . Now, such behavior feints at running back and forth, as contrasted with actual runnings-back-and-forth, we shall define as ideations" (6, p. 210).

I do not claim that the meager data which are reported in the preceding pages fully establish this position; they merely make it seem plausible. They also suggest possible experimental procedures which might lead to a demonstration of the role of such "behavior feints" in learning and thinking.

There is a possibility of still another interpretation of *VTE*. One might assume that the difficulty confronting the animal at the point of choice brings about a state of restlessness which expresses itself in a running-back-and-forth. However, if we consider learning to involve a steady *decrease* of the difficulty at the choice point, it would be hard to see why there is a consistent increase of *VTE* until the habit is mastered. It is for this reason that such an interpretation does not seem to be a plausible one.

Summary

From material collected for about eight years it has been shown that the choosing, or "vicarious trial and error", behavior of rats *when confronted with two possible pathways is directly related to* learning efficiency.

Under a condition of shock for right or wrong responses rats learning a black-white discrimination make fewer errors, while at the same time their frequency of "vicarious trial and error" behavior is greater than when they are not shocked.

"Vicarious trial and error" behavior reaches its highest frequency about the time when errors disappear. It then decreases again and tends to drop out altogether when conditions are suitable, as in a Y-shaped discrimination box.

"Vicarious trial and error" behavior occurs even if the choice alleys do not contain any discriminanda, as in the case of a diffuse sound for a left turn and silence for a right turn. In such a case the frequency of its occurrence seems also directly related to learning efficiency.

"Vicarious trial and error" behavior is not to be considered as a

vestige of the turning around in a wrong alley A situation is presented (shock for correct responses) in which the wrong alley is persistently entered for its full length and where *VTE* has a higher frequency than in other situations (shock for wrong responses and no shock) in which the distance traveled by the rats into the wrong alley is gradually decreased

These results should be considered tentative since they were obtained as by-products of experiments performed for other purposes A direct investigation of this problem is now in progress in our laboratory.

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THE BEHAVIOR INVENTORIES AND EXAMINATIONS OF JAPANESE CHILDREN*

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This article aims to present the behavior items obtained from the observations and experiments on normal children from six months to seven years of age The methods of observations and experiments were mostly adapted from Buhler, Gesell, and the Binet tests revised by the writer. The calibration of age levels is as follows, 4, 5, 6, 9, 12, and 18 months, 2, 3, 4, 5, and 6 years

The following is a complete list of behaviour items of each age level:

THE FOURTH MONTH

(1) A deep colored ball or toy is presented, and the child looks at the object

(2) The child holds his head and shoulders high in the prone position

(3) The child moves his arms and legs freely in the prone position

(4). The adult plays with the child and then leaves him suddenly The child cries out or shows displeasure

(5). Turns from side to back and from back to side

(6) Smiles

(7) Laughs loudly

(8) The Ex bends over the child, brings his face close to his, smiles and addresses him in a friendly fashion The child vocalizes "au au"

(9) A toy with handle is placed in the child's hand and he grasps it in palm

(10) When the child is taken up in the adult's arms, he holds his head erect

THE FIFTH MONTH

(1) A rattle is placed in the child's hand, he holds the rattle firmly and moves it about

(2) The child's fingers come in contact with rattle The touched object is grasped

(3) A rattle is moved within reaching distance of the child He grasps the object with one hand

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(4) The Ex puts his hands behind the back of the child in the dorsal position and tries to raise the child up The child raises the upper part of *his body slightly*

(5) The child is placed in a horizontal position on his stomach The upper *part of the body is raised up from the under-surface so that the* child is supported only by his palms

(6) *After the Ex plays with the child, he walks about in the room* The child pursues visually the moving person

(7). *By bending the child's head on one side, the scene is changed* The child looks at the changed view interestingly

(8) White paper is pasted on one cardboard and red paper on the other The two cardboards are presented one by one, until the child is satisfied Measure which is looked at longer

(9) The expressional movements in response to the bottle are different from those in response to the toys

(10). The child shows smiling and positive expressional movements in answer to the Ex's friendly attitude, and negative expressional movements in answer to the angry attitude

The sixth month

(1) A toy which the child has been manipulating is suddenly taken out of his hands The child shows positive efforts to keep it

(2). A colored toy is brought from the foot of the crib towards the child, to catch his eyes, and then moved back again The child raises up his head *and shoulders from under surface*

(3). The Ex puts his hands behind the child's back in the dorsal position *and tries to make the child sit up The child makes an effort to sit up*, and raises up his head and shoulders

(4). The Ex helps the child to tap the table two or three times Then the child continues to tap the table once or twice without help.

(5) The child takes up a toy from the table with one or both of his hands, clutching it with his fingers

(6) The child grasps a cube with the thumb and fingers

(7). The Ex puts a handkerchief on the face of the child in dorsal position The child tries to take it away with his hands.

(8) The child's responses to the known adult differ from those to unknown one

(9). The child smiles at the shadow of light

(10) Sits with support

(11) Turns from back on to his face *and back again*

(12) Laughs when some one plays "bo-peep"

THE NINTH MONTH

(1) The Ex taps on the table before the child who is lying close to the table The child makes similar movements

(2) When the child accidently drops a toy, he turns his head in the direction in which the toy is dropped and looks about searchingly

(3). The child in the prone position moves forwards or backwards or sideways.

(4). While the child is occupying himself with a rattle in one hand, another rattle is offered to his other hand Holding one object he grasps another

(5). The Ex beats two spoons together while the child is watching and then gives him the spoons The child attempts to imitate the movements

(6). The Ex goes through the movement of cleaning the child's nose with a piece of gauze The child grasps the Ex's hand and pushes it away from his face

(7). When the child sees the familiar person about five meters from him, he calls to the person with vocalizations of "ah ah"

(8) The Ex stands beside the child but turns his back to him and is apparently occupied with other things The child attempts to direct the Ex's attention to himself by pulling at Ex's clothing and directing vocalizations at Ex

(9) The Ex stretches out his hands welcomingly and invites the child saying, "come on" The child bends towards the Ex stretching out his hands

(10) Sits without support for a few minutes

(11) Rhythmic movements of the upper part of body on hearing a march

(12) The child spontaneously vocalizes various kinds of sounds as "abba, babba, tatta, titta"

THE TWELFTH MONTH

(1) The child stands up by holding something (chair, mother's hand)

(2) The Ex makes a sudden sound with a whistle and the child looks at the Ex in astonishment

(3) Instructed to say, "Bye-bye", the child bows. Instructed to smile, the child does so

(4) While the child is watching, the Ex puts a toy in a box and covers it with the lid The child takes the lid off and then takes the toy up

(5) A piece of cake with a string attached is placed out of the child's reach and the string is placed near the child's hands He pulls the cake toward him by means of the string

(6) While the child is watching, the Ex takes a doll in his arms and sings the doll to sleep Then the doll is handed to the child He imitates the movements just demonstrated

(7) The child brings two cubes into some kinds of combination, in horizontal row, or placing one cube upon another

(8) The Ex scribbles *on a sheet of paper* with a pencil and then hands the pencil to the child The child imitates the movements

(9) When the child tries to reach his favorte toy, the Ex. puts a screen between the child and the toy Then the Ex. changes the position of the toy and takes the screen off The child finds the former toy and takes it up

(10) The child walks when both hands are supported

(11) The child understands simple commands as "stop", "give me"

(12) The child vocalizes the words. "bu bu" (automobile), "uma uma" (food).

THE EIGHTEENTH MONTH

(1) Walks freely

(2). The Ex shows the child how to tap the table with two spoons and then hands them to him The child imitates the tapping movement

(3) *The Ex. rolls a ball toward the child The child rolls it back to the* Ex

(4). A pencil and a sheet of paper are given to the child He scribbles without Ex's example

(5) The Ex piles up the cubes while the child is watching and then the child attempts to imitate the movements

(6). The child can eat a bit of food with a spoon

(7) The child drinks tea from a cup holding it with both hands.

(8) When distasteful or bitter things to eat are put in the child's mouth, he spits *them out*

(9). While the child is watching, the Ex. puts his favorite toy in a box The box is then taken away and handed to the child after three minutes without the toy The child looks for the object in the box

(10). A picture without colour is shown and then the same picture with colour is shown The child looks at the latter with much more interest than the former

(11). The child climbs up a low chair or the stairs

(12). The child says ten words or more with meaning

THE SECOND YEAR

(1). Saying "Wipe your face (or hand)" a handkerchief is given to him and then the child is able to do so

(2) A picture of familiar objects (train, automobile, dog, horse, cow, cat, hen etc) is shown and the child should name at least four objects

(3). Three cubes are piled in a tower while the child is watching. He imitates by piling up two or more cubes in five minutes

(4) The Ex. asks "Show me your (my) nose, eyes, ears, mouth", and the *child can point* to them successively

(5) The Ex folds a sheet of paper into two equal parts before the child The child can do the same with another sheet of paper

(6). The child plays by putting sand or beans in a box and emptying the box.

(7) Candies wrapped in paper are given to him and the child opens the paper in order to eat them

(8) A small duster or broom is handed to him and the child imitates dusting or sweeping

(9) A picture of two dogs, one twice the size of the other, is presented and the child compares them and can tell which is bigger

(10) The child walks independently carrying toys or cups with his hands

(11) The child says a simple phrase containing two words

(12) Before the child a vertical line is drawn with pencil on a sheet of paper, and then the pencil is handed to the child He copies the line

The third year

(1) The photograph of the child's family is shown and asked "Where is your mama?" "Where are you?" The child points at it correctly

(2) At least one button of the jacket is fastened

(3) The Ex hands a doll to the child and then a tea-cup, saying "Hello Doll! Drink tea!" The child brings the cup to the doll's mouth

(4) Ten red cards and ten blue cards mixed together are presented The child sorts them into two piles of red and blue.

(5). Three objects (doll, bell, car) are put in three different drawers or boxes while the child is watching After twenty minutes the child is asked to take one of three objects out of the drawers or boxes

(6) Before the child, a cross is constructed of one long block and two short blocks The cross is destroyed and then the three blocks are given to the child to make the cross

(7) Copies a circle one third centimeter in diameter

(8) Two lines, one 1/3 cm long the other 1/2 cm, and 1/3 cm apart, in a horizontal position The child is asked to tell which is longer

(9) The child repeats two digits. (31 for exercise, 54 and 26 for test)

(10) Names five objects (paper, pencil, chopstick, tea-cup, and scissors)

(11) Puts on shoes without hooks or laces.

(12) A tower of five cubes is shown Then the child is asked to build up the tower with five other cubes It is not required that he places one on another straight, but the tower must not fall down

The fourth year

(1) Holding a cup of water the child goes to a place three meters away and back

(2) The picture of a mischievous boy or girl is shown, and then the child is asked, "Is it a good boy (girl) or a bad boy (girl)?"

(3) The Ex says to the child, "What must you do when you are

sleepy?" Then another question, "What ought you do when you are hungry?"

(4) Repeats short sentences as follows

(a) A pretty flower blooms. (For exercise)

(b) An aeroplane is flying through the air

(c) An automobile has come towards us rapidly

(5) When the child is watching, four objects (doll, ball, car, automobile) are put into different drawers or boxes After twenty minutes the child is required to take one of the objects out of the drawers or boxes

(6) Gives sex.

(7) Draws a line between the double lines of a cross

(8) The Ex draws a cross with pencil on a sheet of paper while the child is watching and then the child copies it

(9). Repeats three digits

(a) 312 (for exercise)

(b) 648

(c). 597

(10) The child is required to draw a human face with pencil The test is passed if at least the outline of the face, eyes, and mouth are drawn.

(11) Washes the face independently.

(12) A sheet of paper is folded diagonally before the child Then the child imitates, folding another sheet of paper.

THE FIFTH YEAR

(1) Showing a funny picture the Ex says: "Isn't it funny?" "Why?"

(2) The outline of a face drawn on a sheet of paper is placed before the child Then he puts the eyes, nose, and mouth in their proper places

(3) The child is to draw a line in the left figure to indicate how the right figures might be arranged in it

(4) Repeats short sentences as follows:

(a) A pretty flower blooms (For exercise).

(b) *Miss Hanako* is a very good speaker

(c) The dog is eating cake as if he relishes it.

(5) Gives definitions in terms of use The words are as follows, stove, table, horse, and chopsticks

(6) Names the colors red and yellow

(7) Copies square

(8) Compares two weights; 3 and 9 grams

(9). Repeats four digits

4132 (For exercise)

5943

8267

(10) Puts on clothing and shoes

(11) Counts four cents

(12) The child is required to draw a line by the shortest route from the left-hand side to the right-hand side of the maze

THE SIXTH YEAR

(1) Taps with a pencil at full speed At least 70 taps in one minute

(2) The boy throws a ball at a range of one meter, and the girl at a range of 9/10 meter

(3) Arranges three different squares in the order of size

(4) If it is morning, ask "Is it morning or evening?" If it is evening, put the question in the reverse form, "Is it evening or morning?"

(5) A series of pictures, each with one part left out, which is to be supplied by the child

(6) Say "Show me your left hand!" and then "Show me your right ear"

(7) Copies diamond

(8) Words with the first letter, "A" as *Ame* (rain) and *Ashi* (legs) are shown Then the child is required to say the words with the first syllables, "Ha" and "Ka" (one word each)

(9) Reads ten or more letters of the alphabet

(10) The child is required to draw a man He must draw the face with eyes, nose and mouth, both hands and legs, and the body

(11) The Ex adds 3 cents to 7 cents and says "How many cents are there?"

(12) The child can play a kind of backgammon with four rules The percentage of children who passed the examination of each age level is shown in the following tables

According to Table 1, 4 and 5 of the five months behavior items are difficult and children of seven months of age pass them On the contrary 10 of the six month items is easy and 83 per cent of children pass it before six months of age Six and 11 of the six month items are very difficult and are passed at the end of seven months of age The number of children who pass 6 of the nine month items increases with age up to the end of seven months and then becomes irregular The reason is that holding nose for cleaning is something to which he is accustomed and also the child comes to know its purpose Eleven of the nine month items seems to depend upon the influence of family

According to Table 2, q of the twelve month items is easy and most of the children pass it at nine months of age However 6 of twelve month's items is difficult It may depend upon his treatment at home All tests of eighteen months are easy and all children pass them at the end of sixteen months of age

TABLE 1

FROM FIVE MONTHS AND ONE DAY TO TEN MONTHS AND THIRTY DAYS

Age	Behavior items	*5 1-5 30	6 1-6 30	7 1-7 30	8 1-8 30	9 1-9 30	10 1-10 30
		6	13	15	9	9	8
	1	100					
	2	100					
	3	100					
	4	100					
4 months	5	100					
	6	100					
	7	100					
	8	100					
	9	100					
	10	100					
	1	67	89	100			
	2	100	100	100			
	3	67	100	100			
	4	50	89	100			
5 months	5	84	89	100			
	6	100	100	100			
	7	100	100	100			
	8	100	100	100			
	9	67	89	100			
	10	67	89	100			
	1	33	85	90	100		
	2	0	41	80	100		
	3	50	78	80	100		
	4	50	62	70	100		
	5	16	85	90	100		
6 months	6	0	31	70	100		
	7	16	85	100	100		
	8	16	69	80	100		
	9	33	69	70	100		
	10	83	100	100	100		
	11	0	15	60	100		
	12	66	85	90	100		
	1	16	25	33	56	89	100
	2	0	75	80	100	100	100
	3	0	0	53	78	100	100
	4	0	58	70	78	100	100
	5	0	13	27	56	79	100
	6	33	75	80	67	79	75
	7	0	25	53	67	100	100
	8	0	25	33	78	89	100
	9	0	58	80	100	100	100
	10	16	33	70	100	100	100
	11	0	25	53	67	89	100
	12	16	33	80	100	100	100

*5 1 means five months and one day

TABLE 2

FROM EIGHT MONTHS AND ONE DAY TO NINETEEN MONTHS AND THIRTY DAYS

Age	Behavior items No	8 1- 8 30 9	9 1- 9 30 9	10 1- 10 30 8	11 1- 11 30 5	12 1- 12 30 8	13 1- 13 30 13	14 1- 14 30 6	15 1- 15 30 11	16 1- 16 30 5	17 1- 17 30 6	18 1- 18 30 8	19 1- 19 30 5
	1	11	44	50	100	100	100	100					
	2	44	89	100	100	100	100	100					
	3	11	11	25	100	100	100	100					
	4	11	11	75	100	100	100	100					
12 Months	5	0	11	50	60	75	85	100					
	6	0	11	25	40	63	85	100					
	7	11	11	25	80	100	100	100					
	8	0	0	38	60	75	92	100					
	9	11	11	25	60	75	92	100					
	10	11	22	38	100	100	100	100					
	11	0	33	50	100	100	100	100					
	12	33	44	63	100	100	100	100					
	1					50	54	83	91	100	100	100	100
	2					25	31	33	64	80	83	88	100
	3					38	39	50	55	80	100	100	100
	4					25	23	33	64	100	100	100	100
	5					14	15	17	27	80	100	100	100
18 Months	6					14	15	17	36	100	100	100	100
	7					25	54	66	91	100	100	100	100
	8					63	77	83	82	80	100	100	100
	9					14	8	50	45	80	100	100	100
	10					25	31	33	45	80	83	100	100
	11					25	39	67	73	100	100	100	100
	12					0	8	17	18	60	83	88	100

TABLE 3

FROM SIXTEEN MONTHS AND ONE DAY TO FOUR YEARS

Age	Behavior items No	16 1-16 30	17 1-17 30	18 1-18.30	19-1-19 30	20 1-20 30	21 1-21 30	22 1-22 30	23 1-23 30	2 1-2 6	2 7-6	3 1-3 6	3 7-4
		5	6	8	5	6	6	6	8				
	1	20	33	50	60	66	83	83	100				
	2	0	17	38	60	66	66	83	100				
	3	0	17	50	60	66	66	83	100				
	4	20	17	38	60	66	66	100	100				
	5	0	17	25	20	33	66	66	75				
2 years	6	40	50	50	60	100	100	100	100				
	7	40	66	75	100	100	100	100	100				
	8	20	17	25	33	50	66	66	75				
	9	0	0	0	20	50	66	66	75				
	10	60	83	88	100	100	100	100	100				
	11	40	66	75	80	100	100	100	100				
	12	0	17	25	40	50	66	83	100				
	No									28	20	10	10
	1									14	95	100	100
	2									32	70	100	100
	3									70	100	100	100
	4									39	80	100	100
	5									54	65	90	100
	6									57	90	100	100
	7									47	85	90	100
	8									50	90	100	100
	9									39	85	100	100
	10									43	80	100	100
	11									82	90	100	100
	12									89	95	100	100

*2.1 means two years and one month

TABLE 4
FROM TWO YEARS AND ONE MONTH TO SEVEN YEARS

Behavior items No	2 1- 2 6	2 7- 3	3 1- 3 6	3 7- 4	4 1- 4 6	4 7- 5	5 1- 5 6	5 7- 6	6 1- 6 6	6 7- 7
	28	19	10	10	10					
1	6	89	100	100	100					
2	0	42	60	80	100					
3	0	42	80	100	100					
4	0	48	80	100	100					
5	0	48	70	80	100					
6	0	68	80	90	100					
7	0	16	70	100	100					
8	0	21	70	90	100					
9	0	48	80	90	100					
10	0	16	60	90	100					
11	3	37	80	100	100					
12	0	32	60	90	100					
No			10	10	10	10	7	19	20	
1			10	10	50	70	86	95	100	
2			10	20	70	90	100	100	100	
3			0	0	50	80	100	100	100	
4			0	10	30	40	57	84	100	
5			0	10	30	50	71	84	100	
6			10	30	70	90	100	100	100	
7			0	10	60	90	100	100	100	
8			20	30	50	90	100	100	100	
9			0	10	20	70	86	94	100	
10			40	70	90	100	100	100	100	
11			0	10	30	90	100	100	100	
12			0	0	30	90	100	90	100	

TABLE 4 (*continued*)

Behavior items No	2 1- 2 6 28	2 7- 3 19	3 1- 3 6 10	3 7- 4 10	4 1- 4 6 10	4 7- 5	5 1- 5 6	5 7- 6	6 1- 6 6	6 7- 7
No					10	10	10	10	34	15
1					20	80	100	100	100	100
2					10	80	100	100	100	100
3					20	80	100	100	100	100
4					0	30	80	100	100	100
5					0	10	20	80	82	100
6					0	30	60	70	88	100
7					0	10	70	80	94	100
8					0	0	40	60	79	100
9					0	0	40	60	74	100
10					0	10	60	80	100	100
11					0	10	80	90	94	100
12					0	0	40	60	82	100

Six, 7, and 11 of the two items are easy and they may be used as the tests of twenty-one months No 3 of the three-year items is passed by 70 per cent of children at the beginning of two years of age

The difficulty of 2 and 10 of the four year items depends upon family influence. As 5 of five years items requires the passing of four problems, the number of children passed is less Nos 1, 2, and 3 of the six year items are easy and may be used as the standard of five years of age Nos 5, 8, 9, and 12 of the six year items are influenced by family conditions

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MENTAL AND PHYSICAL CHANGES IN OLD AGE*

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SUBJECTS

The subjects were 355 healthy men and women from 70 to 100 years of age The numbers of each age are given in Table 1

TABLE 1

THE NUMBERS OF SUBJECTS

Age	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Men	5	14	14	16	21	13	13	12	13	9	5	11	8	5	9
Women	3	9	12	15	17	13	10	12	6	10	11	14	5	8	6
Total	8	23	26	31	38	26	23	24	19	19	16	25	13	13	15

Age	85	86	87	88	89	90	91	92	94	96	97	98	100
Men	1	4	2	3		1			1				
Women	8	4	2	1	2	1		1		1	1	1	1
Total	9	8	4	4	2	2		1	1	1	1	1	1

METHODS

Five tests were used strength of grip, rate of tapping, peg board, rote memory of words, and geometrical construction

1 *The strength of grip.*

The Smedley's dynamometer was used Two trials with each hand, right and left alternately, were done As the index of the strength the records of two grips of each hand were averaged

2 *The rate of tapping*

The Veeder's counter was used. The subjects tapped for one minute, using either right or left hand.

3 *The peg board test*

The subjects inserted small round pegs one by one into the small hole of the board for one minute with their right hand and then with the left hand The results were considered in terms of the actual number of holes filled

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4 *The rote memory of words*

The tests were the reproduction of 3-term-, 4-term-, 5-term-, 6-term-, and 7-term-lists heard by the examinee The system of scoring memory for words is as follows: each correct word correctly placed counts 4; each correct word misplaced counts 2, omissions or substitutions count 0 The sum of total scores is 100.

5. *The geometrical construction*

It consists of 10 items Each item contains a square, a circle, a triangle, a diamond, or a hexagon and a number of figures which, when put together in the proper way, compose the square, the circle, the triangle, the diamond, or the hexagon The subject is to draw a line in the square (the circle, the triangle, the diamond, or the hexagon) to indicate how the figures might be arranged in it.

Results

1 *The strength of grip*

Tables 2 and 3 show the strength of grip in kg of both sexes

TABLE 2

The Strength of Grip of Men

Age	70	71	72	73	74	75	76	77	78	79	80
No.	5	14	14	16	21	13	13	12	13	9	5
R	26,0	28,9	30,3	31,2	29,5	28,2	28,2	28,6	26,9	24,1	22,2
L	22,9	28,0	30,9	29,0	27,5	26,9	27,9	26,9	23,6	22,3	23,1
Age	81	82	83	84	85	86	87	88	90	91	94
No.	11	8	5	9	1	4	2	3	1	1	1
R.	26,3	27,2	28,3	24,9	23,0	21,3	27,7	21,7	28,0	15,5	10,5
L	25,8	23,4	24,7	24,4	22,0	21,3	26,0	19,8	30,0	16,0	10,0

TABLE 3

The Strength of Grip of Women

Age	70	71	72	73	74	75	76	77	78	79	80	81	82
No	3	9	12	15	17	13	10	12	6	10	11	14	5
R.	21,6	18,6	20,4	20,3	16,3	18,9	18,5	18,4	17,8	17,1	17,1	15,0	18,9
L	19,0	16,3	20,2	18,7	15,5	17,2	18,1	17,7	17,0	16,3	15,4	13,4	18,1
Age	83	84	85	86	87	88	89	90	92	96	97	98	100
No.	8	6	8	4	2	1	2	1	1	2	1	1	1
R.	16,2	15,2	15,3	12,0	17,4	8,5	16,8	13,0	21,0	14,4	17,5	6,5	12,0
L	15,4	13,7	13,4	12,2	16,3	7,3	15,3	9,0	19,5	14,2	11,5	4,5	11,0

The decrease of strength with age is not clearly indicated in the above tables If the scores are grouped into classes of five year intervals, the decline with age is markedly shown in Tables 4 and 5

TABLE 4

THE STRENGTH OF GRIP IN 5 YEAR INTERVALS

Age	70-74	75-79	80-84	85-89	90-94	95-100
Men R	29,2	27,2	25,8	23,3	18,0	—
Men L	27,7	25,5	24,3	22,3	18,7	—
Women R	19,4	18,1	16,5	14,4	17,0	10,1
Women L	17,9	17,3	15,2	12,9	14,3	10,3

TABLE 5

THE MEAN VARIATION OF THE STRENGTH OF GRIP

Age	70	71	72	73	74	75	76	77	78	79	80
Men R	5,4	4,8	3,6	4,4	4,7	4,2	5,7	6,3	4,5	4,3	4,8
Men L	4,9	4,6	4,0	3,4	4,6	5,6	5,6	6,4	4,7	6,4	3,5
Women R	5,4	3,6	3,1	2,9	2,9	2,4	2,6	4,1	2,7	2,5	3,2
Women L	3,5	2,3	2,8	3,0	3,3	2,7	2,1	2,8	2,0	2,7	3,5
Age	81	82	83	84	85	86	87				
Men R	4,6	4,5	4,4	3,9	—	4,9	2,8				
Men L	3,7	5,6	4,5	5,6	—	4,2	4,0				
Women R	3,6	3,2	3,5	2,8	1,7	3,7	3,6				
Women L	2,6	3,5	3,2	2,6	2,3	4,2	1,3				

According to Table 5, the mean variation does not vary in any constant manner with age It means the subjects tested are equally distributed in the strength of grip.

2 *The rate of tapping*

The number of taps executed with right and left hands is given in Tables 6-8

TABLE 6

THE NUMBER OF TAPS OF MEN

Age	70	71	72	73	74	75	76	77	78	79	80	81	82
No	5	12	13	14	18	11	10	9	11	6	4	7	4
R	243	228	260	307	251	262	243	253	249	219	266	218	242
L	205	215	261	270	234	239	226	230	240	198	240	211	224
Age	83	84	85	86	87	88	89	90	91	94			
No	3	7	1	3	1	3	1	1	1	1			
R	242	254	250	167	294	246	240	297	251	160			
L	183	235	230	172	294	214	220	217	243	100			

TABLE 7

THE NUMBER OF TAPS OF WOMEN

Age	70	71	72	73	74	75	76	77	78	79	80	81	82
No	2	9	10	10	13	11	11	8	5	9	9	12	3
R	212	250	244	230	219	230	212	239	225	246	231	222	191
L	182	201	218	225	202	208	196	218	218	188	194	181	168
Age	83	84	85	86	87	88	89	90	92	96	97	98	
No	7	5	6	2	2	1	1	1	1	1	1	1	
R	220	217	189	167	195	129	260	138	290	228	157	226	
L	205	204	194	137	174	134	226	133	268	192	148	178	

TABLE 8

THE NUMBER OF TAPS IN FIVE YEAR INTERVALS

Age	70-74	75-79	80-84	85-89	90-94	95-100
Men R	258	245	244	239	236	—
Men L	237	227	219	226	187	—
Women R	231	232	202	188	214	204
Women L	206	206	190	173	201	104

If the entire range is divided by five, the scores of each class interval are as given in Table 8

According to the table of numbers classified into five year intervals, the declination of the number of taps is clearly shown. But the decrease of the number of taps with age is not so great as that of the strength of grip

Table 9 shows that there are no constant variations with age.

TABLE 9

THE MEAN VARIATION OF THE RATE OF TAPPING

Age	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
Men R	31	39	38	31	37	41	71	34	32	49	19	38	32	48	36	—	46	—	44
Men L	41	34	39	36	44	32	41	24	29	44	10	31	42	60	34	—	10	—	30
Women R	18	44	33	26	40	28	16	24	42	25	19	26	35	25	36	28	33	16	—
Women L	3	29	22	28	28	28	25	24	23	33	31	33	23	15	37	40	8	3	—

3 *The peg board test.*

The number of pegs inserted is given in Tables 10-12

According to Table 11 the scores of peg board do not fall regularly with increasing age, but the fall is shown more clearly than that of tapping.

The scores grouped into classes of five year intervals are as shown in Table 12

TABLE 10

THE NUMBER OF PEGS INSERTED BY MEN

Age	70	71	72	73	74	75	76	77	78	79	80	81	82
No.	5	16	13	16	21	13	11	12	13	8	5	11	8
R	27,8	27,6	28,8	29,0	26,5	26,3	27,5	27,0	23,5	24,7	27,6	23,3	24,9
L	26,2	25,1	24,4	25,3	23,7	24,2	24,2	25,4	23,6	20,8	22,2	21,7	22,0
Age	83	84	85	86	87	88	90	91	94				
No	5	9	1	3	3	3	1	1	1				
R	24,0	33,0	21,0	16,3	22,7	22,7	30,0	26,0	14,0				
L	21,6	20,9	20,0	12,0	20,7	21,3	29,0	24,0	10,0				

TABLE 11

THE NUMBER OF PEGS INSERTED BY WOMEN

Age	70	71	72	73	74	75	76	77	78	79	80	81	82
No.	3	9	12	15	16	13	11	12	6	11	11	14	5
R	27,3	28,2	25,5	28,1	27,1	26,3	26,1	24,9	24,5	25,5	27,0	22,3	24,0
L	27,3	25,0	25,2	25,6	25,1	25,8	26,5	22,2	22,5	24,7	23,8	22,6	23,8
Age	83	84	85	86	87	88	89	90					
No	8	6	8	4	2	1	2	1					
R	21,8	25,0	22,4	18,2	25,5	17,0	21,5	22,0					
L	20,5	25,0	23,8	17,1	22,5	16,0	21,0	23,0					

TABLE 12

THE SCORE OF PEG BOARD IN FIVE YEAR INTERVALS

Age	70-74	75-79	80-84	85-89	90-94
Men R	27,9	25,8	24,6	20,7	23,3
Men L	24,9	23,6	21,7	18,5	21,0
Women R	27,2	25,5	24,0	20,9	22,0
Women L	25,6	24,3	23,1	20,1	23,0

TABLE 13

THE MEAN VARIATION OF PEG BOARD SCORES

Age	70	71	72	73	74	75	76	77	78	79	80	81
Men R	3,7	2,4	2,2	2,2	3,4	3,2	5,1	2,7	3,6	3,1	4,9	2,9
Men L	3,3	2,7	2,1	2,2	3,2	2,2	5,2	3,2	3,0	2,8	4,2	1,8
Women R	1,8	3,4	4,2	3,8	3,1	3,3	2,4	4,3	2,8	3,0	3,6	3,1
Women L	1,8	2,4	3,0	3,8	3,9	3,2	1,2	2,1	1,8	2,9	2,6	2,9
Age	82	83	84	85	86	87	88	89				
Men R	4,0	2,4	3,6	—	2,6	3,6	4,9	—				
Men L	2,6	2,6	4,1	—	3,3	3,6	4,9	—				
Women R	2,8	4,7	2,3	4,2	4,2	1,5	—	5,5				
Women L	3,4	3,9	3,7	2,6	4,2	1,5	—	5,0				

The constant changes with age cannot be demonstrated from Table 13

4 *The rote memory of words.*

The scores and the mean variations are given in Tables 14-16

TABLE 14

THE SCORES OF ROTE MEMORY

Age		70	71	72	73	74	75	76	77	78	79	80
Men	No.	4	13	10	10	17	10	10	9	6	8	3
	Score	47,5	44,3	36,8	48,0	38,8	41,1	36,3	42,9	44,6	37,6	46,6
Women	No	2	6	10	13	9	10	10	10	3	7	6
	Score	42,5	38,3	33,4	42,0	38,8	38,3	28,3	32,6	30,7	28,3	28,7
Age		81	82	83	84	85	86	87	88	89	90	
Men	No	10	8	5	7	1	3	2	2	1	1	
	Score	40,9	44,0	29,6	31,2	28,0	25,3	28,0	41,0	24,0	48,0	
Women	No	11	5	7	4	7	4	2	1	1	1	
	Score	27,7	28,8	20,3	34,0	28,9	16,0	39,0	50,0	12,0	16,0	

TABLE 15

THE SCORES IN FIVE YEAR INTERVALS

Age	70-74	75-79	80-84	85-89	90-94
Men	43,1	40,6	38,5	29,7	48,0
Women	39,0	31,6	27,9	29,2	16,0

TABLE 16

THE MEAN VARIATION OF THE ROTE MEMORY SCORES

Age	70	71	72	73	74	75	76	77	78	79	80
Men	5,5	8,3	10,2	11,2	6,4	10,1	9,4	12,6	8,5	6,8	7,5
Women	12,5	13,7	10,6	12,6	14,0	8,4	9,4	8,4	5,8	6,0	9,6
Age	81	82	83	84	85	86	87	88			
Men	10,0	7,0	6,9	10,3	—	8,9	26,0	23,0			
Women	10,2	15,4	9,3	13,0	9,3	2,0	2,0	—			

According to the above tables the men do not show a marked declination of scores up to 82 years of age, but then show a sudden drop. On the contrary, the women do rapidly decrease up to 80

years of age and then show a gradual declination The mean variation does not exhibit the difference with age

TABLE 17

THE SCORES OF GEOMETRICAL CONSTRUCTION

Women											
Age	70	71	72	73	74	75	76	77	78	79	80
No	5	15	14	16	21	12	12	12	13	7	5
Men											
Scores	5,0	4,7	6,2	7,4	6,1	6,2	5,7	5,8	4,3	6,0	6,2
No	3	9	12	14	15	13	11	12	6	11	11
Women											
Scores	4,3	3,7	2,8	4,7	3,2	3,1	2,7	4,3	4,2	4,4	3,2
Age	81	82	83	84	85	86	87	88	89	90	91
No	11	8	7	7	1	4	3	2	1	1	1
Men											
Scores	5,0	6,3	4,5	4,0	3,0	1,2	4,0	6,0	2,0	4,0	5,0
No	13	5	8	6	8	4	2	1	2	1	—
Women											
Scores	3,6	1,8	2,3	3,2	2,3	2,5	2,5	6,0	2,5	4,0	--
Age	92	94	96	97	98	100					
No	—	1	—	—	—	—					
Men											
Scores	—	3,0	—	—	—	—					
No	1	—	1	1	1	1					
Women											
Scores	7,0	—	1,5	1,0	3,0	0					

TABLE 18

THE SCORES OF GEOMETRICAL CONSTRUCTION IN FIVE YEAR INTERVALS

Age	70 74	75-79	80-84	85-89	90-94	95-100
Men	5,9	5,6	5,2	3,2	4,0	—
Women	3,7	3,7	2,8	3,3	5,5	1,8

TABLE 19

THE MEAN VARIATION OF SCORES OF GEOMETRICAL CONSTRUCTION

Age	70	71	72	73	74	75	76	77	78	79	80
Men	1,9	2,2	2,4	2,3	2,4	3,3	2,4	3,0	2,3	2,0	2,6
Women	0,9	1,8	2,3	1,4	2,2	2,1	1,9	1,6	1,8	2,4	1,5
Age	81	82	83	84	85	86	87	88			
Men	2,7	3,0	2,3	0,9	—	0,8	2,9	3,0			
Women	1,8	1,7	2,1	2,2	1,5	1,5	0,5	—			

5. *The geometrical construction*

The scores of geometrical construction test and the mean variation are shown in Tables 17-19.

The men's scores decrease very gradually up to the age of 82 and then drop suddenly. The declination of women's scores is not marked up to the age of 80, and is thenceforth rapid

Conclusions

1 The subjects were all in good health. So the scores of five tests do not clearly show the decrease with age, and when the scores are grouped into classes of five year intervals the decline appears. However, the subjects over 90 years of age often show nearly the highest scores

2 Grips need bodily strength, tapping quickness combined with strength, and peg insertion dexterity. The declination with age is clear in the case of grip and peg insertion, and is less so in the case of tapping

3. Memory and construction which need higher mentality do not show a sudden fall up to the age of 82, and then decrease gradually

4 In all tests the scores of 72 or 73 years of age are high, and the death rate of all Japanese decreases at the same ages

5. The individual differences do not change with age Only the peg board test is highly exceptional The fact that there is no individual difference shows that all the subjects are strong

6 Men surpass women in grips and construction of figures The sex differences in tapping and peg inserting are slight. Many writers say the rote memory of adult women is superior to that of adult men, but the present result shows the opposite

7 The declination with increasing age shows almost the same tendencies in both sexes.

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THE NEURAL BASIS OF INNATE BEHAVIOR II RELATIVE EFFECTS OF PARTIAL DECORTICATION IN ADULTHOOD AND INFANCY UPON THE MATERNAL BEHAVIOR OF THE PRIMIPAROUS RAT*[1]

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Purpose

The present series of experiments is the second in a sequence of related investigations dealing with the function of the brain in the mediation of instinctive behavior In the first paper of the general program (1) we reported findings to the effect that a primiparous rat deprived of cortical tissue approximately 30 days before parturition displayed a pattern of maternal behavior differing from that of the normal female In the preparation for parturition (nest-building, etc.), conduction of parturition, and care of the litter for the five days following delivery, the cortically-operated females were inferior to normal controls Furthermore, the degree of inferiority was directly proportional to the amount of cortical tissue destroyed Locus of lesion appeared to be unimportant

The purpose of the present investigation has been to compare the maternal behavior of rats partially decorticated in adulthood with that of females subjected to cortical operation in infancy Data for the maternal behavior of primiparous animals operated upon in adulthood were available in the results of our first investigation To obtain records upon animals operated in infancy we have repeated the experiments devised for our first study, using as subjects primiparous rats subjected to cortical operations at ages varying from one to thirty days.

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Findings of Other Investigators

Experimental literature pertinent to the present problem is limited. In the writings of Foerster (2) and of Gierlich (3) are found reports to the effect that brain injuries occurring in childhood, and infantile hemiplegia, may be followed by more rapid and more nearly complete recovery than similar conditions arising in adult life.

Lashley (6) states that, "it is generally recognized that the outlook for restitution of function (after brain lesions) is somewhat better in young than in older individuals."

Kennard (5), studying the effects of lesions to the motor and premotor areas of young monkeys, found that the rate and extent of recovery in very young operates were markedly superior to those in the adult animal. In one of Kennard's subjects, a 10-day old infant, one entire hemisphere was removed. The recovery shown by this animal within 24 hours was equal to that shown by an adult several weeks after the operation.

Jacobsen, Taylor and Haslerud (4) used the same animals as Kennard and studied the faculty of immediate recall. This function appears to be permanently abolished by lesions restricted to but involving all of the frontal association areas. The permanence of this effect is characteristic of both infant and adult operates.

Martin and Rich (7) found that chicks suffering complete decerebration may show scratching-in-litter activity if the operation is performed prior to the 10th day of life. Later operations appear to obviate this behavior's development.

Tsang (8) investigated the maze-learning abilities of rats hemidecorticated at 21 days of age. When the performance of such animals was compared with that of control groups subjected to partial decortication in adulthood, it was found that lesions of less than 10 per cent of the cortex inflicted in adulthood were followed by as much or more loss in the maze habit as destruction of 40 per cent of the cortex in infancy.

In a subsequent investigation of the pattern vision of animals deprived of the striate cortex in infancy, Tsang (9) found some evidence for a primitive sort of pattern discrimination in the infant operates.

Apparatus, Subjects, Technique

1. *Apparatus*

In planning the present investigation every effort was made to

duplicate the technique and apparatus used in the first series of experiments.[2] The experimental cage, in which all tests of maternal behavior were conducted, was three feet square with sides one foot high. The cage was divided in half by a thin partition pierced in the center by a small doorway which permitted the animal to pass from one half to the other. The cages and partitions used in this investigation were constructed of ply-wood. The cages used in Series I were of the same material, but the partitions in those cages were about four inches wide and consequently constituted a more effective barrier to the passage of stimulating noises and odors than did the partitions used in the present work. Lids of wire mesh were hinged upon each cage.

The single major departure permitted in constructing the cages used for this investigation was the addition of a release box to be used in the retrieving test. These boxes were six by four by three inches and were fastened against the outer wall of the cage at the floor level. A sliding lid was placed upon each release box and a sliding door, raised by the experimenter, opened from the box directly into the cage. One such release box was fastened to each half of the cage.

One hundred strips of paper towelling one by ten inches were suspended from the top of the sides of the cage. These strips could be detached by the rat, and served as nest-building material. A food dish and water bottle were placed in each half of the cage. One half of the cage was lighted by a 15-watt bulb in a conical metal shade. This light could be shifted from one side of the cage to the other.

2. *Experimental Animals*

Because Series I and Series II were conducted in different laboratories, the subjects used were drawn from two different colonies. To make possible the accurate evaluation of differences in experimental results produced by differences in the two animal stocks, and by involuntary and unrecognized changes in experimental technique, all tests of maternal behavior in the present experimental series were administered to a control group of 23 normal, primiparous females.

The original plan of the investigation was to perform operations upon animals varying in age from 1 to 30 days. Practical tests soon proved that while very young rats will survive the surgical shock

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[2]Hereafter the name Series I will be used to designate our first series of experiments dealing with operations in adulthood, and the present investigation will be referred to as Series II.

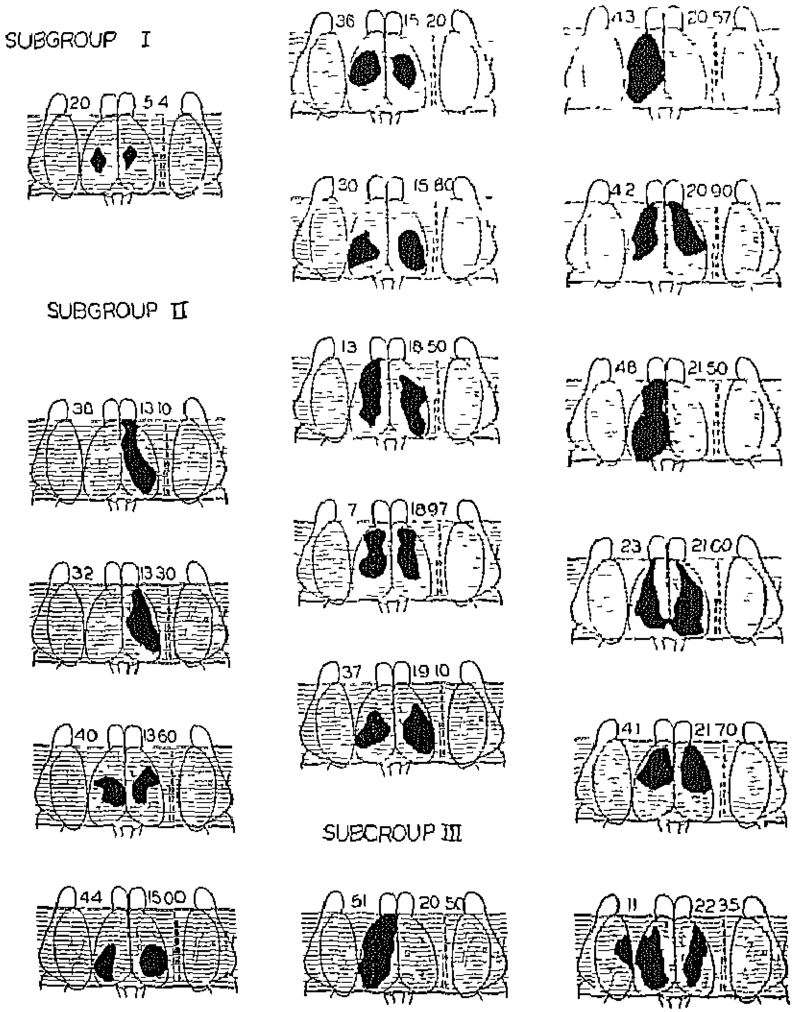
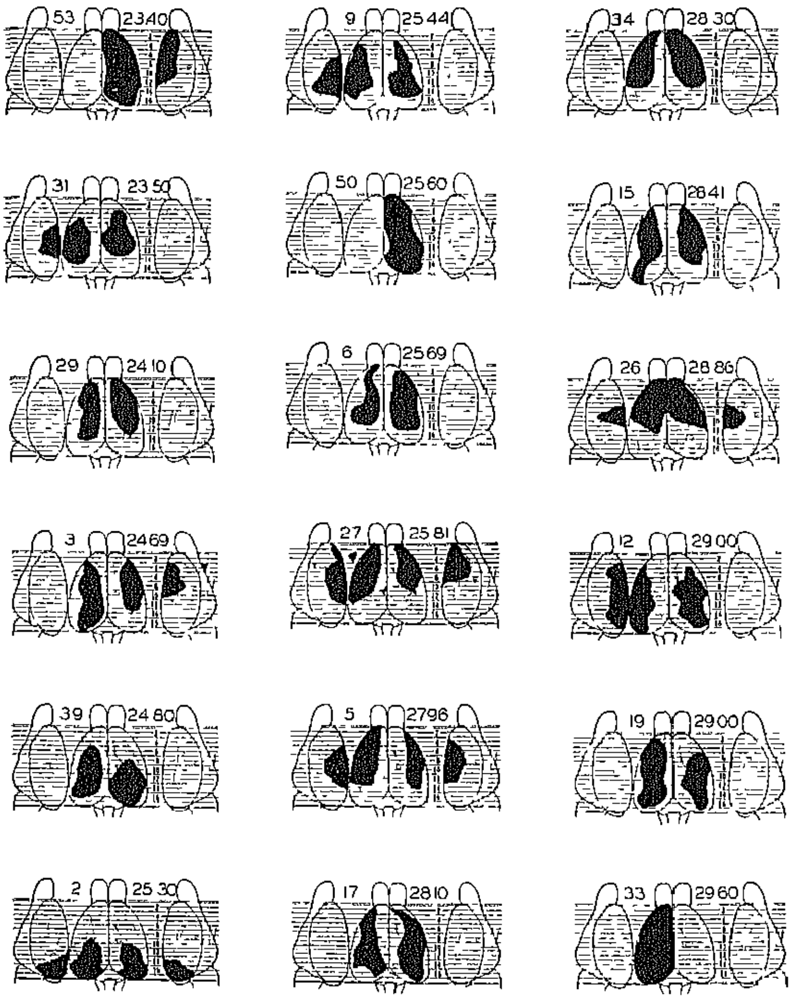

SUBGROUP I
20 5 4
SUBGROUP II
38 13 10
32 13 30
40 13 60
44 15 00
36 15 20
30 15 80
13 18 50
7 18 97
37 19 10
SUBGROUP III
51 20 50
43 20 57
42 20 90
48 21 50
23 21 60
41 21 70
11 22 35

PLATE I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9 2544
34 2830
31 2350
50 2560
15 2841
29 2410
6 2569
26 2886
3 2469
27 2581
12 2900
39 2480
5 2796
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17 2810
33 2960

PLATE II

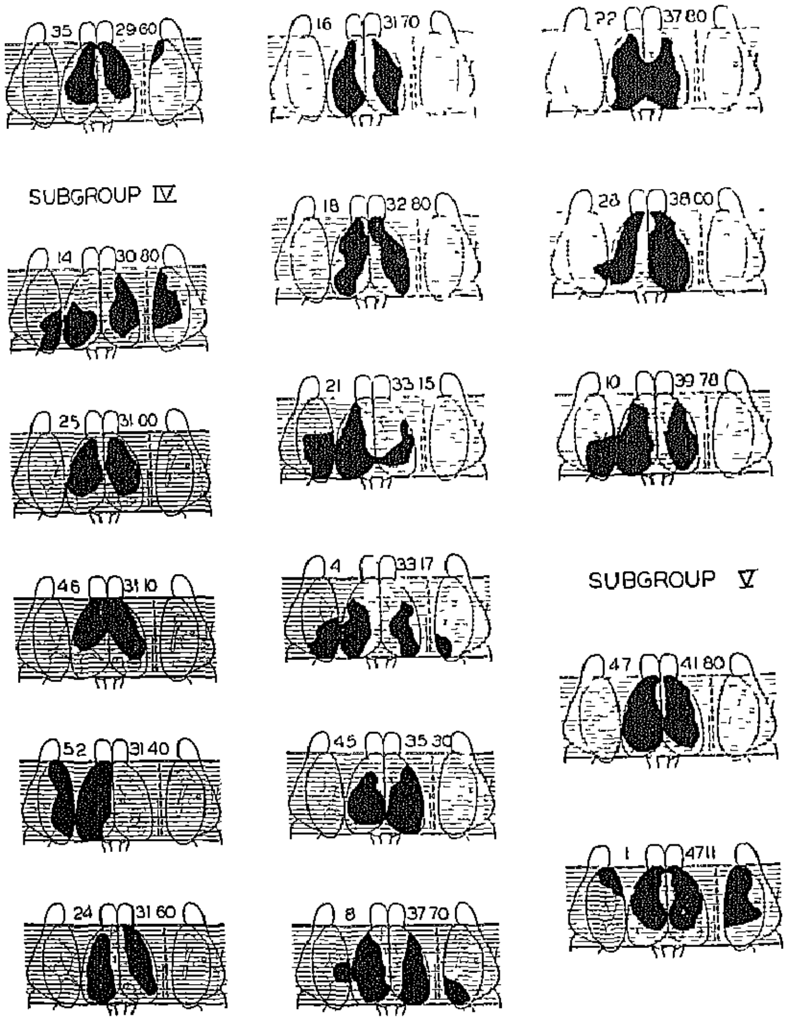

35 29 60
16 31 70
22 37 80
SUBGROUP IV
18 32 80
28 38 00
14 30 80
25 31 00
21 33 15
10 39 78
46 31 10
4 33 17
SUBGROUP V
47 41 80
52 31 40
45 35 30
24 31 60
8 37 70
1 47 11

PLATE III

attendant upon the infliction of large cortical lesions, it is difficult to keep such animals alive. The experimental operated group which attained maturity and cast litters includes a single female operated upon at one day of age, 3 animals operated in the eighth day of life, and 50 cases subjected to partial decortication at 30 days of age

3 *Experimental Technique*

Normal controls and cortical operates were selected by the split-litter technique in order to hold as constant as possible the influence of hereditary differences Operations were performed with the usual aseptic precautions while the animal was under a deep anaesthesia After they had spent a few days in individual hospital cages the operated animals were placed in the same cages with controls Normals and operates were raised under identical conditions

Females were impregnated at ages varying from 90 to 100 days Five days before parturition each pregnant animal was placed in one of the observation cages described above

The following *tests of maternal behavior* were conducted:

a The observation cages were situated in a dark room, and the light above one half of the cage was shifted from side to side in chance order. The 100 strips of paper towelling were suspended from the top of the cage sides and the animals were supplied with plenty of food and water daily During the 5-day pre-partum period daily records were made of the amount of paper detached from the walls, location, number and quality of nests built, and preferences for light or dark half of the cage

b At the time of parturition the following data were noted and recorded (*a*) size of litter, (*b*) per cent of litter well cleaned of fetal membranes, (*c*) per cent of litter collected into one group, (*d*) per cent of litter alive, (*e*) per cent of litter on the dark side of the cage, (*f*) grade of nest.

c. Within 24 hours after parturition the first retrieving test was administered In this test the female was placed in the release box on that half of the cage opposite her nest The young were scattered about both halves of the cage and the female was allowed to enter At intervals after the release of the female records were taken with respect to the number of young retrieved to the nest, number moved elsewhere, and incidental observations upon the activity of the female

The time intervals used were 30 seconds, 1 minute, 5 minutes, 10 minutes, 30 minutes, 1 hour, 3 hours, 12 hours, and 24 hours, from

the beginning of the retrieving test. Any young left unretrieved at the completion of the 24-hour retrieving test were returned to the mother by the experimenter

d A few hours after the completion of the first retrieving test the light was shifted to the opposite half of the observation cage This brought the nests and litters of dark-preferring females into the light Records were made of movements of nest and litter during the succeeding 24 hours

e Upon the third day post-partum a small electric fan was turned on the nest The blast was relatively gentle and in most cases did not destroy any well-constructed nest The female was allowed 24 hours in which to move her young and nest to a protected position

f Upon the following day an electric heater was directed upon the nest and litter The heating element was sheathed in a metal cap to reduce the illumination and the heat emitted The heater was placed on top of the cage approximately 4 feet from the nest, and the intensity of the heat was such that a pup could not survive if left in the direct line of the heater for the duration of the 24-hour test The heater was left directed upon the nest until the female had removed nest and pups to the cool half of the cage, or until the 24-hour experimental period had expired

g During the fifth day post-partum a second retrieving test was given This test was identical with that administered upon the first day of the experiment, with the exception of the additional factor of nest-destruction Before the female was allowed to leave the release box, the nest was destroyed and the young scattered Records taken were similar to those made during the first test, and in addition notes were made regarding the rebuilding of the nest.

The rigorous nature of some of the tests, and the failure upon the part of some operated females to clean, collect, and care for newborn young, resulted in the death of many pups before the conclusion of the 5-day experimental series In Series I an animal was dropped from the tests as soon as her entire litter had perished, even though she had undergone only a part of the series of test situations In the present investigation if an animal's litter died before the completion of all tests, a foster litter was substituted The scores made by animals with foster litters are not included in the computation of averages used to compare results of Series I and II, but later we shall consider the performance of such cases.

Experimental Results

It will be remembered that in the original investigation dealing with cortical mechanisms and maternal behavior we found a disintegration of the normal behavior pattern following the infliction of cortical lesions. The maternal behavior of the operated animals in Series I lacked the integrated character of that shown by normal controls. The extent of this disintegrative effect of cortical destruction appeared to be directly proportional to the amount of tissue excised. We were unable to find evidence proving an unequal functioning of specific cortical areas. No particular area seemed to be essential to the performance of any or all of the maternal responses tested. But with the destruction of given amounts of cortical tissue, regardless of locus, various elements of the total behavior pattern dropped out or appeared in abnormal form.

With these previous results in mind the data of the present investigation were inspected to determine the following points:

(*a*) Does partial decortication in infancy interfere with the performance of the maternal pattern when it makes its first appearance in adult life?

(*b*) If such an interference exists is there any relationship between the total amount of tissue removed and the severity of effect?

(*c*) If such a relationship exists how does it compare in direction and magnitude with the effects observed in adult operates?

In order to make this analysis of data the operated animals were divided into five subgroups on the basis of the size of lesion involved. For the time being we are interested only in percentage of cortex destroyed. Locus of lesion, age at the time of operation, and other factors are temporarily disregarded.

TABLE I

Division of Cortically-Operated Cases into Subgroups on the Basis of the Size of Lesion

Number of subgroup	Limits of lesion in percentages	Number of cases	Average lesion in percentages
I	1-9	1	5.4
II	10-19	9	16.0
III	20-29	26	25.0
IV	30-39	14	34.0
V	40-49	2	45.0

In Table 1 may be seen the distribution of operated cases divided into subgroups comparable to those used in our first investigation.

It is immediately apparent that Subgroups I and V are too small to be considered reliable. In the subsequent presentation and discussion of data these two groups will be represented merely to indicate the general trend of results.

The scores of these subgroups upon all experimental tests are presented in the following series of tables. To facilitate comparisons between the performance of infant operates and those animals operated upon in adulthood the scores of the subgroups in both investigations are presented one above the other in each table. Because all animals are not represented in every test, the number of individuals contributing to each average shown in these tables is given in the parentheses directly following the average in question.

We have said that a control group of normal females was tested in both experimental investigations, and, to show the variations resulting from differing experimental stocks, and changes in technique, the scores of these two normal groups are also represented in each table. In many of the tests it will be found that the two control groups differ in performance. Therefore any difference between infant and adult operates must, to be significant, exceed the difference in control scores on the same test.

1. *Nest-Building Material Detached Pre-Partum.*

Table 2 shows the average per cent of paper strips detached from the cage walls upon successive days pre-partum. In this test the performances of the two control groups differ somewhat. The controls in Series II exceed the other normal group on the fourth, third, and second days pre-partum. Both control groups, however, detach about half of the strips upon the first day in the observation cage (five days pre-partum), and upon the day of parturition they have taken down practically all of the strips.

In the 1 to 9 per cent lesion groups no reliable comparisons are available until the second day pre-partum, at which time the infant operate surpasses the adult operate group. For parturition the infant operate detaches 25 per cent more of the material than does the adult operate group.

The 10 to 19 per cent groups show a fairly consistent difference in favor of the adult operates up until the first day pre-partum, at which point the performance of the groups is about equal.

TABLE 2

AVERAGE PER CENT OF PAPER STRIPS DETACHED FROM THE CAGE WALLS UPON SUCCESSIVE DAYS PRE-PARTUM

Subgroup	Series	Percentages detached on successive days pre-partum 5	4	3	2	1	Parturition
Control	I	57(14)	58(21)	58(30)	75(33)	84(35)	98(36)
Control	II	56(18)	76(19)	83(19)	83(20)	89(21)	97(21)
I	I	55(3)	73(3)	53(6)	57(8)	68(8)	75(8)
I	II			20(1)	81(1)	100(1)	100(1)
II	I	59(8)	57(10)	56(12)	60(13)	72(15)	90(15)
II	II	28(6)	30(8)	32(8)	42(9)	77(9)	93(9)
III	I	31(4)	26(7)	20(11)	25(13)	33(14)	86(14)
III	II	26(16)	38(18)	36(22)	41(24)	52(25)	78(24)
IV	I	10(4)	8(6)	8(8)	13(8)	22(8)	51(8)
IV	II	13(8)	19(13)	31(13)	43(13)	64(14)	64(14)
V	I	1(1)	2(3)	5(4)	10(6)	27(7)	31(7)
V	II	1(2)	10(2)	21(2)	23(2)	25(2)	74(2)

The Roman numerals under the heading Subgroup refer to the grouping of cortical operates explained in Table I Roman numerals under the heading Series refer to the present and the preceding experiment as explained in the footnote on page 111 Numbers presented in parentheses following each average indicate the number of animals contributing to that average

In the records of the 20 to 29 per cent groups the infant operates are superior upon four of the five days pre-partum, but this superiority does not persist on the day of parturition

The infant operates with from 30 to 39 per cent cortical destruction detach more material than the adult operates throughout the entire observational period This superiority of the infant operates is free from inversion

Series II animals with lesions of more than 40 per cent of the cortex show higher scores than adult operates with lesions of similar size upon all but the fifth and first days pre-partum At the time of parturition the infant operates have detached 43 per cent more material than the adult operate group.

Inspection of Table 2 will show that while both investigations yield evidence for a direct relationship between the amount of cortex destroyed and the extent of deterioration in the activity measured, this relationship is much more marked in the case of the adult operates However, despite several inversions in the relationships of the subgroups of the infant operates, it is evident that on the whole the larger lesions produce more interference with this behavior than do the smaller amounts of cortical invasion

As far as detaching of nest-building material in advance of parturition is concerned it appears that there is no consistent difference in the performance of adult and infant operates with lesions of less than 30 per cent of the cortex. Operations involving more than this amount seem more detrimental to the performance of this activity when performed in adulthood than in infancy. The performance of the control groups indicates no significant difference in technique or experimetal groups as measured by this test

2. *Grade of Nests Built*

It has been stated that nests built were graded The scale of five points is described in detail in our report of Series I (1) and pictures of representative nests are therewith presented At this point suffice it to say that the criteria taken into consideration in grading a nest were as follows thickness and firmness of flooring, extent, width and height of walls, and compactness of structure The 5-point nest represents the best structure observed, whereas a 1-point nest is little better than the collection of a few paper strips into one cage corner.

In Table 3 may be seen the comparative performances of all subgroups and controls in the two investigations. Here, as in the detach-

TABLE 3

AVERAGE GRADE OF NESTS BUILT UPON SUCCESSIVE DAYS PRE-PARTUM

		Days Pre-Partum					
Subgroup	Series	5	4	3	2	1	Parturition
Control	I	1 0(14)	1 0(21)	7(30)	1 1(33)	1 8(35)	4 0(36)
Control	II	1 3(18)	1 5(19)	1 3(19)	1 4(20)	1 9(21)	3 6(21)
I	I	2 0(3)	2 0(3)	2 0(6)	1 4(8)	1 9(8)	2 0(8)
I	II			1 0(1)	2 0(1)	4 0(1)	4 5(1)
II	I	6(8)	8(10)	8(12)	1 2(13)	1 1(15)	2 0(15)
II	II	4(6)	6(8)	5(6)	7(9)	1 6(9)	2 5(9)
III	I	0(4)	0(7)	0(11)	2(13)	3(14)	2 0(14)
III	II	6(17)	6(18)	5(22)	8(24)	1 0(25)	2 3(24)
IV	I	0(4)	0(6)	0(8)	0(8)	2(8)	8(8)
IV	II	1(8)	3(13)	4(13)	4(13)	1 0(14)	2 7(14)
V	I	0(1)	0(3)	0(4)	0(6)	0(7)	1(7)
V	II	0(2)	1(2)	1 0(2)	8(2)	8(2)	2 0(2)

The Roman numerals in the first two columns, and the values given in parentheses, are explained in Table 2

ing of strips before parturition, the normal groups vary but little, and the small differences that do exist are inconsistent, favoring first the infant and then the adult group. We may conclude, therefore, that any consistent differences of reasonable magnitude between operated subgroups in Series I and II are truly the result of the different ages of operation, and not the effect of different stocks or altered technique

The two most important aspects of this measure of maternal activity are, first the number of days before parturition when nest-building is initiated, and, second, the excellence of the nest at the time that the litter is cast In considering the first criterion we must disregard the smallest-lesion groups, for the single animal in Subgroup I of Series II was not placed in the observation cage until the third day pre-partum. The normals and the four remaining subgroups show an interesting trend. The control groups in both investigations begin nest-building at approximately the same level of excellence upon the first day in the observation cage (five days before parturition) In the records of animals with from 10 to 19 per cent of the cortex destroyed, we find that nest-building is begun upon the fifth day pre-partum Nests built at this early date are poor, not comparable with those of the normal controls.

Adult operates with from 20 to 29 per cent of the cortex removed build no nests until the second day before parturition Infant operates with comparable lesions initiate nest-building activity upon the fifth day pre-partum

In considering the subgroups with from 30 to 39 per cent of the cortex destroyed we find that adult operates build only upon the first day before parturition, while infant operates begin nest-building, at a very low level, upon the fifth day pre-partum

Subgroup V records show that neither infant nor adult operates with lesions of over 40 per cent display any nest-building activity upon the fifth day pre-partum. Four days before the birth of the litter, however, the infant operate group displays limited nest-building activity. On the third day pre-partum the nests built by these animals operated in infancy are of a higher grade. In contrast to the performance of Subgroup V in Series II, the animals with more than 40 per cent of the cortex removed in adulthood show no nest-building at all until the day of parturition, and even at this late date the nests built by this subgroup are extremely poor

When we come to consider the second important trend represented

in Table 3, namely the grade of nest built at the time of parturition, we find that whereas the two control groups have average nests that are approximately equal in excellence, all five subgroups of operated animals show an unvarying superiority in favor of the infant operate groups. Not only do the infant operates in each subgroup build better nests than adult operates with similar amounts of cortical destruction, but it is also apparent that the superiority of the infant operates tends to increase with increasing size of lesion.

Summarizing the findings represented in Table 3, we may draw the following conclusions. (*a*) Cortical lesions inflicted in infancy, as well as those inflicted in adulthood, result in marked deficiencies in the nest-building activity of the parturient female. Both in respect to the date at which this activity is initiated, and as we consider the final result of the activity (the grade of nest at parturition), we find the operated females falling below normal control group averages. (*b*) The degree of deficiency in the case of the adult operates is closely related to the amount of cortex destroyed. The same relationship, though not so clearly defined, appears in the records of the subgroups of infant operates. On the whole, the larger-lesion groups show averages falling below those of the animals with smaller amounts of cortical invasion. (*c*) While the infant operates are inferior to the normal controls in nest-building activity, they are definitely superior to animals operated upon in adult life. Inspection of subgroup averages shows that infant operates initiate nest-building at an earlier date, and build better nests than do the adult operates.

3. *Parturition Data*

In Table 4 and Figures 1 and 2 may be found the data gathered with respect to the parturition of all experimental groups.

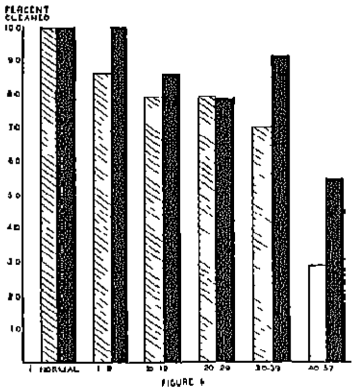
The differences in size of litter appear to favor Series II females. They are slight, and since the records of normal groups reveal a similar trend there is no evidence in operated subgroup scores that would lead us to attribute this increase in litter size to the fact that the cortical operations involved were performed in infancy.

The care of the litter at the time of delivery offers one of the most reliable pieces of evidence for the general level of maternal behavior. This part of the pattern, as measured by our techniques, is probably the least affected by experimental conditions. The innateness of this behavior is beyond serious question and its biological importance is obvious.

TABLE 4
DATA DEALING WITH PARTURITION

Subgroup	Series	Number of young	Per cent well-cleaned	Per cent well-collected	Per cent alive	Per cent on dark side
Control	I	8(36)	100(36)	100(36)	97(36)	83(36)
Control	II	9(22)	100(22)	100(22)	96(22)	90(22)
I	I	7(8)	87(8)	75(8)	100(8)	75(8)
I	II	5(1)	100(1)	100(1)	100(1)	100(1)
II	I	8(14)	79(14)	86(14)	98(14)	82(14)
II	II	10(9)	87(9)	75(9)	95(9)	62(9)
III	I	8(15)	79(15)	85(15)	96(15)	82(15)
III	II	9(22)	78(24)	68(24)	87(24)	70(24)
IV	I	7(7)	70(7)	34(7)	98(7)	76(7)
IV	II	9(14)	92(14)	85(14)	92(14)	64(14)
V	I	8(1)	29(7)	14(7)	57(7)	71(7)
V	II	10(2)	55(2)	50(2)	100(2)	61(2)

The Roman numerals in the first two columns and the values presented in parentheses are explained in Table 2



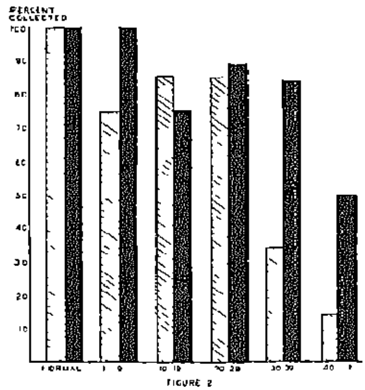


FIGURE 1

PERCENTAGE OF LITTER CLEANED AT PARTURITION BY CONTROLS AND SUBGROUPS OF SERIES I AND SERIES II

Crosshatched bars represent the performance of Series I animals, and solid bars show the averages for Series II cases

FIGURE 2

PERCENTAGE OF LITTER COLLECTED INTO ONE GROUP AT PARTURITION BY CONTROLS AND SUBGROUPS IN SERIES I AND SERIES II

Crosshatched and solid bars have the same significance as in Figure 1

We find, by inspection of Table 4 and Figure 1, that all normal control animals in Series I and II cleaned 100 per cent of the litter upon delivery Fetal membranes were completely removed, placentae were devoured, and young were licked clean This tendency to care for the new-born young is decreased in the adult operate group with a lesion involving only 1 to 9 per cent of the cortex. As increasing amounts of cortical tissue are removed, a larger and larger per cent of the litter is left uncleaned, until females with more than 40 per cent of the neopallium destroyed clean only 29 per cent of the litter

In the animals subjected to cortical operation during the first 30 days of life we find that small lesions of less than 10 per cent are followed by little or no loss in the cleaning tendency Animals in Subgroup II of Series II clean 87 per cent of the litter With the exception of the inversion shown in the average of Subgroup IV (30-39 per cent) we find in the records of the infant operates the same type

of relationship between efficiency of performance and size of lesion as is present in the scores of the adult operates. The severity of the loss shows a direct relationship to the amount of cortical tissue removed.

However, although infant operates, like those animals operated in adulthood, show a relationship between amount of tissue destroyed and extent of behavioral loss, this loss is much less marked in the infant than in the adult operate group. This superiority of the infant operates is present in four of the five subgroups. Furthermore, it is clear that the extent of the infant operate superiority increases with increasing size of lesion. The superiority of Series II animals in Subgroup I is 13 per cent; Subgroup II, 8 per cent, Subgroup IV, 22 per cent, and Subgroup V, 26 per cent.

Figure 1 illustrates this series of relationships quite clearly. In studying this figure the following three functions should be carefully noted: (*a*) the subnormal performance of cortically-operated groups regardless of the time of operation, (*b*) the tendency shown in the subgroups of both investigations for the severity of loss to bear a direct relationship to the amount of cortical tissue removed, and (*c*) the superiority of the infant operate group over the adult operates, and the tendency for the degree of this superiority to increase with increasing size of cortical lesion.

The normal primiparous female gathers her new-born young into the nest either during or at the completion of parturition. A cortically-operated animal, in contrast, may leave some of the new-born young scattered about the cage floor. Table 4 and Figure 2 show that the loss in this aspect of the maternal behavior pattern is comparable to that described for the cleaning tendency. Without going into a detailed analysis of the results of this test we note the following facts: (*a*) Normal controls in both series collect all young into the nest. (*b*) Operated groups show subnormal averages on this test. (*c*) The degree of loss on the part of the cortical operate appears to be definitely related to the size of lesion involved. This holds true for both infant and adult operates. (*d*) The infant-operate subgroup averages, while definitely below normal performance, tend to be superior to the averages of the adult operate groups. (*e*) This superiority of the infant operates becomes more and more marked as the size of the lesion increases. Figure 2 illustrates this group of functions.

The fourth column of averages in Table 4 shows the average per

cent of litter alive upon discovery by the experimenter. The control groups show a difference of one per cent, indicating no essential variation in experimental stocks or technique. While there are differences in the averages of the five subgroups for the two series, we are inclined to believe that no genuine difference of function exists for this measure. Most of the differences are small and they are not consistent in direction, three favoring the adult operate animals (but showing an average superiority of only 6.6 per cent), one favoring the infant operates by 43 per cent, and one being equal.

The final column of averages in Table 4 illustrates the tendency of all animals to cast their litters in the dark half of the cage. In the scores of controls and subgroups for Series I we find no difficulty of interpretation. There is a marked spread of individual differences, but on the whole approximately three-fourths of the litters of both control and operated animals are cast on the dark side of the cage. There is no evidence that would lead us to postulate any effect of cortical lesions upon this function. Operated animals with very large lesions display approximately the same direction and degree of preference as do controls and operates with smaller lesions.

In the records of animals in Series II there appear several apparent ambiguities. The equality of normals and operates is less definite, and there is a slight indication of an inferiority on the part of the cortically operated cases with lesions exceeding 20 per cent of the neopallium.

4. *Retrieving Activity*

The retrieving activity during the first test is represented in Table 5. The records of the two control groups of normal animals display a remarkable intra-group consistency which testifies to the constancy of the experimental techniques herein involved. The average retrieving time in number of minutes-per-pup is relatively the same for these two groups.

In considering the records of the subgroups of operated cases we find ample evidence that cortical destruction interferes markedly with retrieving activity. There are a few inversions in the relationships between the records of controls and the smallest-lesion subgroups, but on the whole the superiority of the normals seems definitely established.

It is evident, further, especially in the records of the adult operates, that as the size of the lesion increases the speed and completeness of the retrieving activity decreases. This direct relationship between

TABLE 5

AVERAGE PER CENT OF LITTER RETRIEVED TO NEST AT SUCCESSIVE INTERVALS AFTER THE BEGINNING OF THE FIRST RETRIEVING TEST

		Time elapsed since start of test									Average number of min per pup
Subgroup	Series	30 sec	1 min	5 min	10 min	30 min	1 hr	3 hrs	12 hrs	24 hrs	
Control	I(36)	7	16	61	83	90	93	96	97	100	30(36)
Control	II(23)	8	10	19	71	80	91	95	96	100	23(23)
I	I(8)	2	5	52	58	70	79	79	79	79	71(7)
I	II(1)	0	25	25	25	25	100	100	100	100	5(1)
II	I(15)	10	14	50	65	78	79	82	83	92	65(13)
II	II(9)	1	5	30	50	68	78	83	83	89	40(13)
III	I(15)	1	5	22	35	52	58	67	76	87	103(13)
III	II(22)	4	9	41	55	73	73	80	86	89	117(22)
IV	I(7)	2	5	25	36	36	36	36	38	43	131(8)
IV	II(14)	1	4	39	48	66	76	81	86	86	57(14)
V	I(2)	0	0	7	14	14	14	14	14	14	129(2)
V	II(2)	4	8	20	50	50	50	50	50	50	80(2)

The Roman numerals in the first two columns are explained in Table 2. Values presented in parentheses in the second and last columns show the number of animals represented by the averages presented.

the general efficiency of the response and the amount of intact neopallium is less clearly defined in the records of the subgroups of infant operates There is indication that lesions exceeding 30 per cent of the cortex are followed by an interference more marked than that occasioned by smaller amounts of destruction

Let us next consider the comparison between adult and infant operates In Subgroup I of both series we find a superiority in favor of the infant operates The consistence and magnitude of this superiority is marked, but we have repeatedly emphasized the unreliability of this particular intra-group comparison because of the fact that a single case represents the performance of the infant operate group

In Subgroups II and III (with 10 to 19 and 20 to 29 per cent cortical destruction respectively) there is little evidence of any reliable difference between the performance of adult and infant operates The situation changes when we consider those females with lesions of more than 30 per cent of the cortex Here we find a rather pronounced difference in favor of the animals subjected to partial decortication in infancy In Subgroup IV (30 to 39 per cent) the infant operates establish their superiority in the first five minutes of the retrieving test, and thereafter the intra-group difference increases in magnitude until at the completion of the test the adult operates have retrieved only half as many young as have the infant operate group

The comparison between adult and infant operates subjected to destruction of more than 40 per cent of the cortex, while based upon relatively few cases, supports the evidence yielded in the foregoing comparisons of Subgroups IV In this, the largest-lesion group, we find retrieving beginning earlier, occurring more rapidly, and continuing until a higher percentage of the young are in the nest, in the scores of the infant operate group After 24 hours, the adult operates have retrieved only 14 per cent of their young, whereas those females operated upon in infancy have retrieved 50 per cent

The average retrieving time expressed in minutes-per-pup shows that infant operates are decidedly superior to adult operates when the cortical lesions involved exceed 30 per cent of the total neopallium

As far as retrieving activity during the first test is concerned we may draw the following conclusions

(*a*) Cortical operations, regardless of the age at which they are performed, are followed by decrements in the speed and completeness

of retrieving (*b*) The decrement involved appears to be somewhat proportional to the amount of cortical tissue excised Evidence for this principle is best found in the records of animals operated in adulthood, but may also be discerned in the averages of the infant operates. (*c*) The animals operated upon during the first 30 days of life show less serious disturbance in retrieving than do adult operates, providing the cortical lesions exceed 30 per cent.

5 *Response to Environmental Changes*

The response of the experimental animals to various alterations in the environment is shown in Table 6. Here are represented the average percentages of young moved from under the light, electric fan, and electric heater

Data dealing with response to the placing of an electric light above the nest are full of apparent contradictions There is a difference in the response of the two control groups The Series II controls move 11 per cent more young than do normal animals in Series I However, in the records of the subgroups of operated animals we find a consistent reversal of this superiority, with adult operates showing higher averages throughout At the same time it is evident that, in the results of the first experimental series, the usual inferiority of operates as compared to controls is absent in this test Here the operated groups score consistently higher than the normals. In the records of the infant operates, on the other hand, we find no such relationship Three subgroups of operates move fewer young than the controls, one subgroup equals the control average, and the largest-lesion subgroup moves 20 per cent more young than the normals.

Before inspecting the response of controls and operates to the electric fan and heater turned on the nest, it is important that we recognize the influence of a powerful selective factor affecting these averages In both series of experiments it was found that those operated animals with large lesions took very little care of their litters. As a result the young of these females could not survive, and upon the day of the electric fan test, the third day post-partum, many of the largest-lesion cases had lost all of their litters An animal whose young were dead was removed from the experiment.[3] As a consequence of this high mortality among the litters of operated females,

[3]In a later section we shall discuss the effect of giving foster young to those animals whose original litters died before the completion of the experiment

TABLE 6

AVERAGE PER CENT OF LITTER MOVED FROM UNDER LIGHT, FAN AND HEATER

Subgroup	Series	Per cent litter moved from light	Per cent litter moved from fan	Per cent litter moved from heater
Control	I	19(36)	74(34)	81(34)
Control	II	30(23)	57(22)	96(22)
I	I	17(6)	83(6)	98(6)
I	II	0(1)	80(1)	100(1)
II	I	46(13)	64(13)	66(10)
II	II	25(8)	50(6)	100(6)
III	I	23(13)	69(13)	68(10)
III	II	7(18)	72(18)	100(16)
IV	I	53(5)	55(5)	50(2)
IV	II	31(11)	60(10)	100(10)
V	I	50(2)	33(3)	no test
V	II	0(2)	0(1)	100(1)

The Roman numerals in the first two columns and the values presented in parentheses are explained in Table 2

the most inefficient mothers were automatically weeded out. A "survival-of-the-fittest" process operated continually to eliminate those operated cases which were unable to adapt as well as the control animals. For this reason the averages presented in Table 6, representing response to fan and heater, are deceptive in that they do not accurately show the extent of the subnormality of operate performances.

If we consider for the moment the record of Series I subgroups in the fan test, it is apparent that all operate averages (with the exception of that of Subgroup I) fall well below the score of the normal controls. Furthermore, Subgroups III and IV, having the largest lesions, perform even less efficiently than do those operates with smaller amounts of cortical destruction. In the averages of Series II groups no such relationship is apparent. Two factors enter into this apparent equality between operates and normals. (We except the records of Subgroups I and V since each represents the performance of a single animal.) Firstly there is some evidence pointing to a difference in the fan test as administered in the two series. Controls in Series II move 17 per cent less of the litter than do normals in Series I. Since different fans were used and distances between fan and nest were not accurately measured, it is not improbable that the effects of the blast were less severe in Series II than in the first investigation. In the second place, we have seen in all data presented thus far that the cortical operates in Series II tend to approach more nearly the norms of their control group than do the adult operated cases. With the evidence at hand we are not justified in drawing any conclusions with respect to the relative performances of controls and operates in Series II.

Cursory inspection of the averages showing response to the electric heater reveals two outstanding relationships. (*a*) In Series I, operated animals tend to make fewer responses than do controls, and the reduction in number of young moved is greater in the case of the larger-lesion animals. (*b*) Infant operates perform much more efficiently in this test than do those animals operated in adulthood. There is in the averages of the two control groups some evidence for difference in the test as given in the two investigations, but on the whole the superiority of the infant operates is greater than this possible inequality of techniques would lead one to expect.

Although present evidence reveals no difference in the response of operates and normals to fan and heater as measured in Series II, it is to

be shown in a subsequent section of the experimental report that operates do actually perform less efficiently than the control group on both of these tests If, in calculating the averages for cortical operates, the scores of those females with foster litters are included, a definite inferiority to normal performance is at once apparent

Data derived from the *second retrieving test* are not presented at this point because of the inadequacy of the Series I records On the fifth day post-partum, when this test was administered, the operated females with large lesions had lost all of their litters Accordingly the only comparisons available in Series I records are those between normals and operates with very small amounts of cortical destruction No significant differences were found in these comparisons Results of the second retrieving test as administered during the second series will be presented later

6 *Survival of Young*

We have said that the neglect of young shown by some operated females, and the severity of several of the tests, resulted in the death of many of the pups In Table 7 may be seen the survival records for

TABLE 7

AVERAGE PER CENT OF LITTER SURVIVING UPON SUCCESSIVE DAYS POST-PARTUM

Subgroup	Series	Days post-partum				
		1	2	3	4	5
Control	I(36)	96	88	69	64	56
Control	II(22)	96	94	94	87	88
I	I(8)	77	75	60	52	48
I	II(1)	100	100	100	100	100
II	I(15)	76	60	47	30	29
II	II(9)	85	77	61	52	52
III	I(14)	80	62	46	24	18
III	II(24)	75	71	64	54	52
IV	I(8)	44	22	9	8	6
IV	II(14)	88	69	60	58	58
V	I(7)	40	12	0	0	0
V	II(2)	95	56	50	4	0

The Roman numerals in the first two columns are explained in Table 2 The values presented in parentheses in the second column indicate the number of animals upon which the following averages are based

the young expressed in terms of per cent of the litter alive upon successive days post-partum. This table shows the following differences: (*a*) The controls in Series II lost fewer young than did the normal animals in the first series. This fact is not to be interpreted as evidence for a more hardy stock in the one case, but is more probably a reflection of the difference in severity of fan and heater tests referred to above. (*b*) In the records of Series I it is plain that a cortically operated animal loses more pups than a control case, and it is equally evident that the rapidity and extent of this loss is directly related to the size of lesion involved. In this series of comparisons there is very little contradiction, and the positions of the various subgroups on the fifth day post-partum show not a single inversion, all operates falling below the control average, and subgroups following regularly in order of magnitude of lesion. (*c*) Animals subjected to cortical operation in infancy show a definite inferiority to controls in this series of averages. With the unimportant exception of Subgroup I which consists of a single case, all operated groups fall well below the normal group. The tendency for inferiority of operates to increase with larger lesions is less marked, if indeed it exists, in these data than in those derived from Series I. (*d*) Infant operates lose fewer pups than adult operates. The superiority of infant over adult operates is more marked in the larger-lesion subgroups.

Comparative Effects of Bilateral and Unilateral Lesions

Series I yielded evidence indicating that unilateral cortical lesions were followed by less marked aberrations of the maternal behavior pattern than were bilateral lesions of comparable magnitude. The data from Series II have been searched for confirmatory evidence. It will be remembered that in his study of infant-operated rats, Tsang (8) found that the losses following infliction of unilateral lesions were much less severe than those resulting from bilateral invasions of the neopallium.

The operated cases in Series II include eight unilateral lesions. Five of these unilateral lesions belong in Subgroup III, falling between 20 and 29 per cent in extent. For present purposes it is sufficient to consider these five cases and forget the remaining three unilateral lesions which are distributed in two other subgroups. In Table 8 are presented comparisons between the unilateral and bilateral cases with lesions ranging from 20 to 29 per cent of the cortex. The superiority

TABLE 8

SHOWING COMPARATIVE PERFORMANCES OF ANIMALS WITH UNILATERAL AND BILATERAL LESIONS OF EQUAL EXTENT

Test involved			Average for bilateral lesion cases	Average for unilateral lesion cases
Material detached on successive days pre-partum	Days pre-partum	5	28	4
		4	34	34
		3	36	40
		2	49	49
		1	53	49
	Parturition		68	97
Nest built on successive days pre-partum	Days pre-partum	5	6	0
		4	6	0
		3	6	4
		2	7	13
		1	9	14
	Parturition		20	35
Parturition data	Per cent of litter cleaned		74	95
	Per cent of litter collected		84	100
First retrieving test	Per cent of litter retrieved	Time 30 sec	6	6
		1 min	8	16
		5 min	30	76
		30 min	44	91
		1 hr	65	100
		3 hrs	74	100
		12 hrs	82	100
		24 hrs	85	100
	Average minutes per pup		150	5
Percentage of litter surviving	Days post-partum	1	78	98
		2	68	98
		3	59	98
		4	48	87
		5	45	87

of the animals with unilateral over those with bilateral lesions is marked and unvarying. These findings, when combined with those of Series I, justify the conclusion that unilateral cortical lesions produce a much less marked effect upon the performance of the maternal behavior pattern than do operations invading both hemispheres of the brain.

TABLE 9

SCORES OF SUBGROUPS IN SERIES I EXPRESSED IN TERMS OF PER CENT OF SCORES OF SERIES II SUBGROUPS ON THE SAME TEST TO ILLUSTRATE THE RELATIONSHIP BETWEEN SIZE OF LESION AND DEGREE OF SUPERIORITY OF INFANT OPERATES OVER ADULT OPERATES

Test involved			Control	I	II	Subgroups III	IV	V
Paper detached on successive days pre-partum	Days pre-partum	5	102		211	119	77	100
		4	76		190	81	42	20
		3	70	265	175	65	26	24
		2	90	70	143	71	30	43
		1	94	68	94	69	34	108
	Parturition		101	75	97	113	80	42
Grade nest built on successive days pre-partum	Days pre-partum	5	77		150	0/6	0/1	0/0
		4	67		133	0/6	0/3	0/1
		3	54	200	160	0/5	0/4	0/10
		2	79	70	171	29	0/4	0/8
		1	95	48	69	33	20	0/8
	Parturition		111	44	80	83	30	5
Parturition data	Per cent litter							
	Cleaned		100	87	91	98	76	53
	Collected		100	75	115	94	41	25
	Alive		101	100	103	110	107	57
	On dark side		92	75	132	106	119	116
Response to Environmental changes	Per cent litter moved from							
	Light		63	17/0	184	329	171	50/0
	Fan		130	104	128	97	92	33/0
	Heater		84	98	66	68	50	0 100

TABLE 9 (*continued*)

Test involved		Control	I	II	Subgroups III	IV	V
Per cent retrieved	Time						
in first test	30 sec	88	2/0	1000	25	200	0/4
	1 min	160	12	280	56	120	0/8
	5 min	321	208	167	56	64	35
	10 min	117	232	130	64	75	28
	30 min	113	280	115	72	55	28
	1 hr	102	79	101	82	44	28
	3 hrs	101	79	101	82	44	28
	12 hrs	101	79	100	88	44	28
	24 hrs	100	79	103	97	50	28
	Average min per pup	130	1420	163	87	230	161
Per cent litter	Days						
Surviving on	1	100	77	89	101	50	42
Successive days	2	94	75	78	81	32	21
post-partum	3	73	60	60	77	66	0/50
	4	74	52	58	41	14	0/4
	5	64	48	50	32	10	0/0

Superiority of Infant Operates as a Function of the Size of Cortical Lesion Involved

Throughout our consideration of the relative effects of cortical operations performed in infancy and in adulthood we have observed that the infant operates are generally superior to adult operates, and further, it has frequently been noted that this superiority is more marked in those subgroups with larger lesions. To clarify this relationship between degree of superiority of infant operates and size of cortical lesion Table 9 has been prepared. In this table are presented the results of those tests in which the infant operates scored definitely higher than the adult operates. The scores of the adult operates on each such test are presented as per cent of the infant operate scores on the same test. To provide an easy method of estimating the degree to which any intra-group difference is due to varying experimental techniques the scores of the control group in Series I are expressed in terms of their per cent of the Series II control scores.

The first column in Table 9 shows this relationship between the two control groups. Upon the fifth day pre-partum the controls in Series I detached 102 per cent as much paper as did the second control group. On the day of parturition, the score of the Series I controls is 101 per cent of the score of the normals in Series II. This difference is negligible when compared to the record of Subgroup V, where adult operates detached only 42 per cent of the amount taken down by infant operates on the day of parturition.

Throughout this series of comparisons a figure of 100 per cent indicates parity between the two groups. These data tell us nothing whatsoever about the absolute differences between the various groups. For example, a score of 100 per cent may mean that both infant and adult operates built a 1.0 nest, or it may just as accurately designate a 3.0 nest. The only thing that the 100 per cent figure means is, that whatever nest was built, the scores of adult and infant operates were equal. In those instances where a zero score is involved no attempt has been made to represent the intra-group difference in terms of percentages, but the absolute score for both groups is presented.

With this explanation of Table 9 in mind let us examine the figures given with a view to determining any possible differences in the superiority of various infant operate groups.

In the pre-parturient activity of detaching paper strips the infant

generally superior, as shown by the majority of per-
ing well below the 100 per cent mark. In considering
on the day of parturition, we find that there is little
the records of the two investigations until we come to
performance of Subgroups IV and V. Here it is evident
of 30 to 39 per cent brings the performance of the adult
vn to 80 per cent of the infant operate level. Lesions
per cent of total cortical area result in even more marked
of adult operates. Thus it would appear that the
f infant operates is confined to those animals with lesions
1 30 per cent, and that, on the whole, lesions of 40 per
er are proportionately more serious than those falling
and 39 per cent.

tion of the comparative grades of nests built by adult and
es shows, briefly, that adult operates definitely tend to be
infant operates, and that this inferiority grows more
as one considers the larger-lesion groups. Adult operates
0 to 39 per cent of the cortex destroyed build only 30
good nests as do infant operates with lesions of similar
the lesion considered is greater than 40 per cent, the
performance drops to 5 per cent of that of the Series II
ntrol groups differ only slightly on this test.

's a graphic representation of one set of values given in
wing the survival records of the litters. It is important
t the differences herein shown are not absolute, but
e fact that the 40 to 49 per cent lesion group falls lowest
the adult operate inferiority in this subgroup is more
han in those with smaller lesions. It can be seen that in
itions there is only one inversion of the relationships of
nd this reversal involves Subgroup I which includes
nt operate. The fact that controls in Series I fall below
e second series has been dealt with in our discussion of

nted in Table 9 and Figure 3 appear to justify the follow-
n. There exists a constant tendency for animals operated
o score higher than adult operates upon our tests of
avior, and, in those cases where this tendency is at all
e superiority of infant over adult operates tends to be
ortional to the magnitude of the cortical lesion involved.

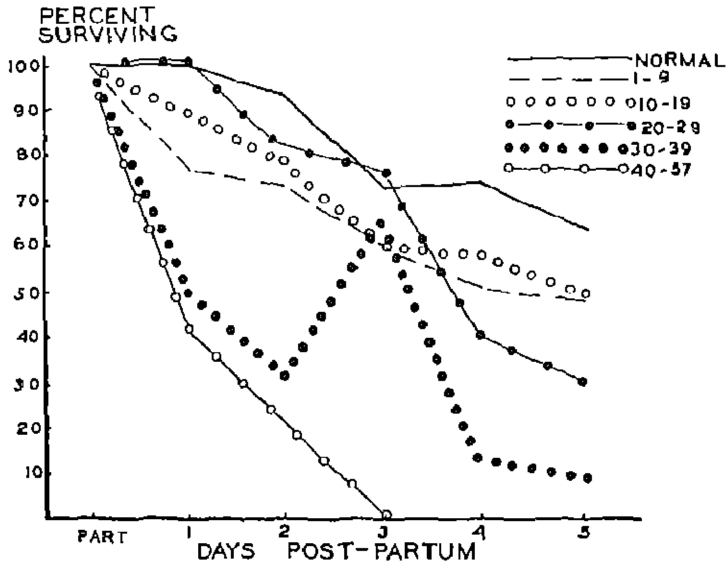


FIGURE 3

SURVIVAL RECORDS OF LITTERS OF CONTROLS AND SUBGROUPS
Series I averages are expressed in terms of percentage of Series II averages
For detailed explanation see text

COMPARISON BETWEEN THE EFFECTS OF CORTICAL OPERATIONS PERFORMED AT 30 DAYS OF AGE AND THOSE MADE DURING THE FIRST 8 DAYS OF LIFE

Fifty of the cortical operations performed in Series II were made upon animals 30 days of age. Three females were operated at 8 days of age, and one was partially decorticated within a few hours after birth. Actually many more operations were performed on very young animals, but these four cases were the only individuals to survive and bear litters.

In Table 10 are presented comparisons between the averages of the 30-day operates and those four cases subjected to cortical invasion within the first 8 days of life. The average cortical lesion is comparable as can be seen from the table. The grade of nests built by the two groups does not differ to any extent. Percentage of litter

TABLE 10

PERFORMANCE OF ANIMALS OPERATED AT 30 DAYS OF AGE COMPARED WITH THAT OF THOSE CASES OPERATED UPON DURING THE FIRST 8 DAYS OF LIFE

Test involved		Average for 30-day operates	Average for earlier operates
Number of cases		50	4
Average cortical lesion		26 34	24 58
Material detached upon successive days pre-partum	Days		
	5	24	5
	4	28	8
	3	32	17
	2	39	34
	1	65	51
	Parturition	79	90
Nests built on successive days pre-partum	Days		
	5	36	00
	4	47	00
	3	50	03
	2	68	50
	1	1 20	1 00
	Parturition	2 50	2 25
Parturition data	Per cent of litter		
	Cleaned	85	81
	Collected	84	75
Response to environmental changes	Per cent litter moved from		
	Light	16	25
	Fan	62	60
	Heater	100	100
First Retrieving test	Time	Per cent litter retrieved	
	30 sec	2	3
	1 min	6	18
	5 min	32	56
	10 min	48	56
	30 min	67	56
	1 hr	71	81
	3 hrs	80	81
	12 hrs	82	81
	24 hrs	86	81
Average min per pup		88	96
Per cent litter surviving on successive days post-partum	Days		
	1	84	81
	2	74	75
	3	64	75
	4	54	75
	5	53	75

cleaned and collected is slightly higher in the case of the 30-day operates No consistent difference is seen in the responses of the two groups to light, fan, and heater In the first retrieving test the performance of the 30-day operates is comparable to that of the younger operates. Survival records of litters are slightly better in the case of the very young operates. These data do not justify any conclusions with regard to possible differences in the effect of operations at 30 days of age and those performed much earlier

Effects of Substituting Foster Litters

In our discussion of experimental methods for Series II it was stated that when a female lost her own litter, through failure to care for the young, she was given a foster litter and subjected to the remainder of the experimental test series In Series I this substitution of foster litters was not made, and as a consequence the differences between operated and control animals became smaller in the later tests.

It was our opinion during the conduction of Series I that the actual differences between operates and controls were just as pronounced in the fan test, the heater test, and the second retrieving test, as they were in those tests occurring during the 36 or 48 hours immediately following parturition. Unfortunately, however, our data did not show this continued inferiority, because the worst cases were automatically eliminated when their litters died To test the accuracy of our prediction that the inferiority of the operates would have been just as marked in later tests, if the entire operate group could have been carried through, we varied the procedure in the present series and substituted foster litters

The results of this substitution may be seen in Table 11 where our predictions are shown to have been accurate Substitution occurred only in Subgroups II, III, and IV The two extreme groups are not considered because they are so small. In these three subgroups the score made by animals which kept at least a part of their original litter alive throughout the tests is given in the column headed O In the adjacent column, headed O+F, are presented the average performances of all females, both those with their own litters and those with foster young

It is at once clearly seen that in all cases the group score is definitely lowered by the inclusion of those cases which performed with foster

TABLE 11

SHOWING THE CHANGES IN AVERAGE PERFORMANCE OF THREE SUBGROUPS WHEN SCORES OF THOSE CASES WITH FOSTER LITTERS ARE INCLUDED IN THE MEANS

Test involved		Subgroup II O	II O+F	III O	III O+F	IV O	IV O+F
Response to environmental changes	Per cent moved from						
	Light	25	22	7	5	31	28
	Fan	50	36	71	52	60	52
	Heat	100	86	100	80	100	84
Second retrieving test	Time						
	30 sec.	5	4	8	7	4	4
	1 min.	10	13	15	12	16	12
Per cent	5 min.	61	49	47	39	47	36
retrieved	10 min.	92	71	58	47	56	44
after start	30 min.	92	71	68	57	66	52
of test	1 hr.	97	80	79	65	92	73
	3 hrs.	97	81	82	68	97	80
	12 hrs.	100	83	84	75	98	90
	24 hrs.	100	96	88	79	98	91
Average minutes per pup		14	69	118	143	41	128

Under the columns headed O are given averages derived from performance of females with their original litters. Under columns headed O+F are given averages derived from performance of all females, those with original and those with foster litters.

litters. In other words, those mothers that lost their own young were definitely inferior to the other cases, and should be included to show the true difference between operates and controls.

Table 11 brings out one more important point. If we compare the performance of the various operated subgroups with foster litter cases included, with control averages, we find that differences between operates and controls are more marked. The response to the heater test is a case in point. It will be remembered that in Table 6 the normals in Series II were shown to have moved 96 per cent of their litters from under the heater, whereas all operated subgroups moved 100 per cent of their young. These data might lead one to conclude that cortical operation has no effect upon this particular tendency to move the young to a protected position. If, however, we consider the records of operated subgroups with foster litter cases included, we find that the three subgroups included in Table 11 show a subnormal performance in this test. Similar comparisons can be made for all other tests represented in this table.

1. *Second Retrieving Test*

We have explained the difficulties preventing the comparison of results of the second retrieving test in Series I and II. At this point we may briefly consider the results of the test as given to Series II animals only. The data gathered in connection with this test as given to Subgroups II, III and IV are presented in Table 11. Control females retrieve more pups and retrieve them more rapidly than do cortically operated cases. There is a slight tendency for the degree of loss in retrieving activity to be correlated with size of cortical lesion. Animals with from 1 to 9 per cent cortical destruction retrieve all young. Removal of more than 40 per cent of the cortex results in complete loss of retrieving activity in the second test.

In giving this test the nest was destroyed. Records of the re-building of nests reveal that normal controls and those females with less than 20 per cent cortical invasion rebuild without fail. Lesions of from 20 to 39 per cent are followed by a slight loss in the tendency to rebuild the destroyed nest, females with cortical destruction between these two limits rebuild only 90 per cent of their nests. The choice of the site for the new nest seems to be affected by partial decortication. Fifty-seven per cent of the rebuilt nests of control animals are constructed at new nest-sites. Of the operated females who rebuilt their nests, an average of 36 per cent chose new nest-sites, and 64 per cent rebuilt at the old location.

Effects of Subcortical Lesions

Careful inspection of cross sections of the operated brains revealed that 13 animals suffered no injury to the subcortex. Subcortical lesions inflicted may be classified as follows. (*a*) The dorsal convexities of the hippocampal lobes were destroyed in 22 animals. (*b*) Relatively minor invasions of the anterior-dorsal extremities of the striatum occurred in 9 cases. (*c*) Thalamic nuclei were invaded in 2 brains. (*d*) Injury to the optic tract and lateral geniculate nuclei was revealed in 2 cases. (*e*) Degeneration of the superior colliculus occurred in 3 cases.

The behavioral records of animals with lesions to the hippocampus have not been compiled. All studies designed to determine the function of these areas of the rat brain have shown that lesions to the hippocampus produce no symptoms other than those resulting from removal of the overlying cortical mass.

The records of the nine animals with small invasions of the striatum have been studied and compared to those of nine other cases showing comparable cortical lesions but lacking any injury to the subcortex. The average cortical lesion of the striatum cases is 4 per cent larger than that of the purely cortical operates In the comparisons of these two groups there is some evidence pointing to a more efficient performance on the part of the animals without lesions to the striatum Females with slight lesions to the striatum score lower than the cortical controls on the following tests percentage of young cleaned at parturition, percentage of young collected at parturition, percentage moved from heater, percentage moved from fan, and percentage of young surviving all tests The differences involved are slight, and before any definite conclusions can be drawn it is necessary to know a great deal about the maternal behavior of females with large striatum lesions

Theoretical Discussion

The observation that cortical operation in infancy is less detrimental to the performance of the maternal behavior pattern than similar decortication occurring in adult life has been made repeatedly in our consideration of experimental results The interpretation of this superiority, while it offers opportunity for numerous stimulating speculations, is exceedingly difficult

The possibility of nervous regeneration in the injured infant brain may safely be disregarded Such regrowth has yet to be demonstrated and all evidence is against its occurrence Histological examination of all operated brains yields no evidence for replacement of injured tissue Present results are based upon measurement of destruction taken from the adult brain Had any destroyed tissue been replaced by regeneration our results would remain unaffected because in such a case the proportion between normal and excised tissue would have been altered before our measurements were made

The theory of diaschisis in relation to brain injuries, advanced by von Monokow, might be brought to bear upon the evidence yielded from this experiment There is, possibly, some "long-time effect" of cortical operation which persists several months after the injury and consequently affects the performance of animals tested within a few weeks after they are subjected to partial decortication If such is the case we may assume that a part or all of the diaschisis is dis-

pelled before the infant operate is tested for maternal behavior However, Lashley and others have paid especial attention to the possibility of diaschisis in connection with studies of cortical function in the rat, and it has been found that the recovery shown 14 days after operation is as nearly complete as that revealed at any later time

In an attempt to explain experimental findings similar to those presented in this report Tsang (8) offers the following interpretation:

> With extensive loss of cerebral tissue, a young brain, by virtue of its high plasticity, reconditions the residual parts for the extra-ordinary integrative duties which are otherwise not required of them (p 242) By virtue of high plasticity of infant brain tissue the general and facilitative forces in the intact parts are promptly organized into dynamic patterns to meet environmental demands In the light of previous studies, this organization is achieved rather in terms of relations and ratios of excitations in the different parts, the specific locality of parts matters little (p 243)

Interpretations such as the above may be applicable to present findings, but until more experimental evidence is available our interpretation of results must be extremely tentative We prefer to defer interpretation of our own results until subsequent investigations, now under way, are completed.

SUMMARY

The present investigation is the second in an experimental series dealing with the neurological correlates of innate behavior In the first investigation primiparous females subjected to cortical operations at 100 days of age were given a series of tests of maternal behavior In this, the second investigation, 54 females were cortically operated at ages ranging from 1 to 30 days At 100 days of age the females were impregnated and subjected to the same tests used in Series I.

Because the two investigations were conducted in different laboratories and with different stocks of animals a control group of 23 normals was included in all tests

Experimental findings appear to justify the following conclusions

1. Animals operated in infancy and those subjected to partial decortication in adulthood tend to be inferior to normal females on tests of maternal behavior.

2 The degree of inferiority of cortical operates shows a direct

relationship to the extent of the lesion, larger lesions producing more severe losses than smaller invasions of the neopallium

3 The loss involved appears to be in the ability to integrate discrete behavior units into a unified whole. Many operated females, for example, carry young about the cage as actively as do normals, but they do not carry them to a common corner or to the nest.

4. Animals operated upon in infancy are superior to those operated in adulthood in the majority of cases Infant operates do not equal control performances but usually exceed the normal of the adult operates.

5. The extent of the infant operate superiority appears to be related to the amount of cortical tissue destroyed. As the size of lesion increases, the degree of superiority of infants over adults grows larger

6 No evidence for an unequal functioning of cortical areas is found.

7 The effects of unilateral invasion of the cortex are less severe than those of bilateral destruction, even though the total amount of tissue excised is the same in both cases.

8 There is slight evidence indicating that the striatum may contribute to the mediation of the pattern of maternal behavior

No theoretical interpretation of experimental findings is presented The need for further investigation of the general problem is stressed

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INFANT DEVELOPMENT UNDER CONDITIONS OF RESTRICTED PRACTICE AND OF MINIMUM SOCIAL STIMULATION: A PRELIMINARY REPORT*[1]

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This is a further report upon the development of female twins born January 19, 1932, and reared in the experimenter's home from February 22, 1932, until March 22, 1933. Previous reports upon the outcome of this investigation have dealt with the establishment of social smiling (2), the effect of restricted practice upon reaching, sitting, and standing (3), and the laterality of function in the subjects (4). The present report deals chiefly with the rate of development of behavior during the period when the environmental conditions of the subjects were most severely restricted, namely, the first seven lunar months (ending on day 192). Later development is treated for the sake of completeness, but it is of less interest as it occurred under circumstances which more nearly approximated American family life.

The circumstances of the twins from the beginning of the experiment to the end of the seventh lunar month were in brief as follows. The sole care of the infants was exercised by Mrs. Dennis and myself. They were fed on a lactic acid cow's milk formula prepared for us by the University of Virginia Hospital. Feedings were approximately at 4-hour intervals. A daily bath was given in a small tub in the nursery and a daily sun bath was given before an open window.

The subjects were kept in individual Kiddie Koops, and were always placed in the supine position. The Kiddie Koops were

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separated by an opaque screen The subjects were taken from their cribs only for feeding, bathing, cleaning, and dressing, and for a few experiments They were taken from their nursery room only for monthly medical examinations at the nearby hospital. No one entered the nursery unless accompanied by one of the experimenters. The infants were not propped up in a semi-sitting position and no toys were given them. Only tree-tops and the sky were visible from the windows of the room, and no pictures or mirrors were hung on the walls The nursery contained a minimum of furnishings.

We did not smile at the subjects nor did we speak to them, romp with them, or tickle them except as these actions occasionally were incorporated into routine experiments We talked to each other when in the nursery but did not direct our remarks to the infants We did not punish the subjects for any act on their part, and we tried to avoid rewarding them for any act, either by praise, patting, or special attentiveness However, when either infant cried insistently, we entered the room and corrected whatever condition seemed to be the cause of the cry We did not adhere rigidly to the feeding schedule If either infant seemed quite hungry before the usual hour, she was fed; and on the other hand neither infant was ordinarily awakened if she was asleep at the usual hour for feeding.

Additional details with respect to the care of the infants will be found in previous reports (2, 3, 4).

Notes on the behavior of the infants were taken each time we entered the room, which we did on the average about 12 times per day.

While some of the restrictions just outlined may seem extreme, it must be borne in mind that they were applied during the first seven lunar months when infants are awake but little longer than is required for feeding, bathing, and dressing. Beyond the seven months' period, the restrictions upon motor practice and upon social stimulation were abandoned one by one. The restrictions were removed not because of any restiveness on the part of the subjects nor because any detrimental effects were apparent, but because the imposition of such conditions is a novel one in child psychology and it was felt that a prolonged experiment of this character should not be undertaken until after the effects of a short period of restriction had been demonstrated

The stringent conditions of the first seven months were subsequently altered as follows.

On day 192, we began to speak to the subjects and occasionally to romp and play with them. The subjects' initial reactions to such behavior were of course recorded.

Beginning with day 254, the infants were often placed prone on quilted pads on the floor for periods of five to thirty minutes daily. Practice in maintaining the sitting posture was begun on days 262 and 263 as reported earlier (3). Placing the subjects in high chairs was started on day 300, and rattles, the only toys which were presented to them, were introduced on day 341. Training in standing with support first occurred on day 364 (3). During the final month of the experiment the infants were introduced to a variety of new conditions, and their environment was no longer of a decidedly restricted sort. However, even at the close of the experiment the majority of their waking hours were spent in the cribs.

Behavioral Development

Mrs. Dennis and I have recently compiled the developmental records of 40 subjects of baby biographies (6). The reader is referred to the original publication for definitions of the items of behavior, as they are too long to warrant repetition in full.

In Figure 1 the notations along the left margin are short descriptions of the behavior items. The horizontal line opposite each notation indicates the age range during which this item made its appearance in the biographies and the short vertical which cuts each horizontal line indicates the median age for the appearance of that item. The figures at the left of the chart indicate the number of reports of each item. All of the infants whose records are on this chart were described as healthy and of normal intelligence, and none was very unusual in the amount of training which was given it. Since less than 40 records, and in some cases only 10 records, are represented for each item, it is altogether likely that the ranges here represented are too narrow.

The circles and triangles show the ages at which each of our subjects first performed the items listed on the chart. The circles indicate the records of the larger twin, named Rey, and the triangles the records of Del, the smaller of the two. A few items show no

FIGURE 1

records for our subjects because in these respects we failed to make observations comparable to the biographical reports

By referring to the chart, it will be seen that with respect to

the items whose upper limits appear within the first seven lunar months, the twin subjects with few exceptions fall within the age range of children with normal environments In the upper half of the chart, the items in which the subjects fall beyond the range of the comparison subjects are chiefly the first three items, which occur at such an early age that it seems unlikely that the retardation of the twins was due to the experiment It seems more likely that this may have been due to the poor nutritional condition of the infants when we received them. Aside from the first three items, the only other apparent retardations among the items which ordinarily appear within the first seven months occur in Rey's case only They are "head up, supine," "object to mouth," and "vocalize two syllables" In none of these cases is Rey more than two weeks beyond the upper range of the biographical subjects, and since records are available in some instances for less than 20 infants, there is a strong likelihood that the ranges here shown are too narrow It is concluded therefore that the records of our subjects within the first seven months are not distinguishable from those of the children whose records have been kept by biographers

A similar conclusion is reached if instead of the biographical data, Shirley's recent data (7) are used for comparison Shirley followed a number of children through the first two years of life, obtaining a longitudinal record of behavioral development We have selected from her tables those behavior items which do not involve special tests, and hence which are comparable to our observational account of development These are shown in Figure 2, which is constructed in the same way as Figure 1 In respect to the 14 items in this chart whose upper ranges fall within the first seven lunar months, our subjects' only retardation is a one-week delay in "startled by sound" on the part of Rey

Such comparisons are of course not ideal, as the different sets of data were gathered by different people and in somewhat different ways Nevertheless, it is believed that they are sufficient to show clearly that no striking abnormalities of development occurred during the period when the environment of the subjects of the experiment was highly restricted

It is of course quite possible that had conditions been normal our subjects might have developed any one of the items at an age dif-

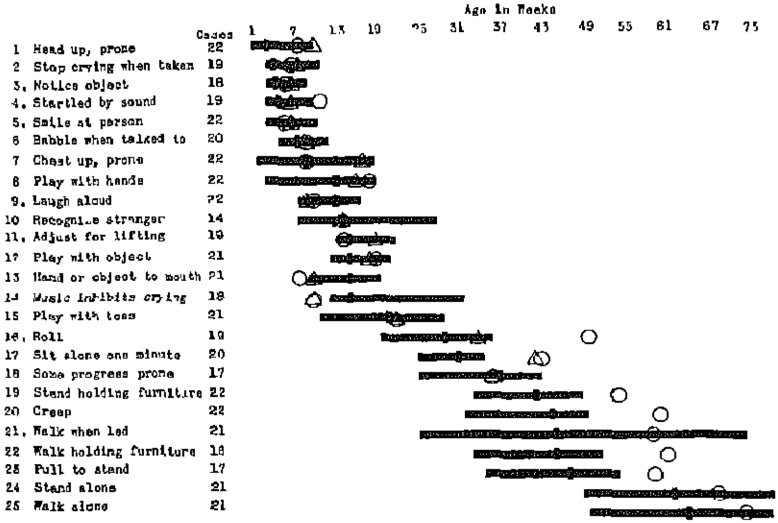

FIGURE 2

ferent from that at which it actually appeared. That slight differences in behavior may have been induced by the experiment, there is no intent to deny, and no means to prove or disprove. But it must be concluded that whatever the effects of the experiment may have been, they were not sufficient to force our subjects beyond the range of infants reared under normal conditions.

After the seventh lunar month, the subjects show some records beyond the range of the comparison cases. The responses in which retardation is greatest are visually directed reaching, sitting alone, and standing with support, and these retardations have been shown in a previous report (3) to be due probably to restricted opportunities for practice. It should be emphasized here, as it has been in the previous publication, that although these responses were absent when first tested for at ages beyond the normal limit, yet each of them was rather promptly established without example and without reward when opportunities for practice were provided. It seems reasonable to suppose therefore that the lack of instruction and of socially administered rewards was not responsible for these

retardations, but rather that they were due to the lack of self-directed practice.

It is necessary to comment on the performance of each of our subjects in respect to the last eight items of Figure 1 and the corresponding items of Figure 2, all of which are locomotor in character. In all of these responses Rey is near or just beyond the upper limit of the control cases She is so near the upper extreme, however, and the number of control cases is so small, that it is uncertain whether the combined restriction of practice and restriction of social stimulation had any effect upon these items Any influence of the experiment upon Rey's locomotion becomes doubtful when we widen our sampling of normal children The upper ranges of Shirley's study are slightly beyond the biographical ranges, and Rey's record is in many respects indistinguishable from the slowest of Shirley's cases, who of course were not deprived of social encouragement or practice. (This fact is not shown clearly by Figure 2 because Shirley was not able to obtain complete data for her most retarded subject)

On the other hand, Del's locomotor performances in the items at the bottom of the chart occurred at ages considerably beyond the upper limits set by the biographical records or by other studies of normal children They are too retarded to be presented on a chart of this width and in consequence are shown in Table 1. The last

TABLE 1

DEL'S LOCOMOTOR ITEMS

	Weeks of Age
Pull to kneeling	77
Stand holding furniture	67
Creep	never
Walk holding furniture	92
Pull to standing	81
Walk when led	81
Stand alone	111
Few steps alone	111

of these items, which is walking alone, occurred only shortly before the second birthday

Certain considerations make it extremely doubtful that this retardation was due to the experiment The subjects of the experi-

ment are now slightly more than six and one-half years old While Rey throughout her history has been essentially normal, it has become apparent during the past two years that Del has some disability of her left arm and leg Her left arm is much more awkward than her right in all respects and is almost unused by her Her left leg is very inferior to the right. Del has been submitted to a thorough clinical examination, and the medical report shows no anomalies of bone or muscle and gives a diagnosis of mild left hemiplegia probably referable to cortical injury at birth. This injury may also be the reason for Del's low *IQ*, which at four and one-half years was 70 while that of Rey was 107 (Stanford-Binet)

Neither the hemiplegia nor the low *I Q* of Del made themselves manifest at an early age It will be seen upon examination of Figure 1 that Del was retarded in practically nothing prior to nine months of age. Extensive movie records taken in the third month reveal no disability on the left side These facts of course agree well with the view that the cortex is very incomplete at that age, and with the recent findings that later intelligence cannot be predicted within the first year (1).

While the special facts of Del's case deserve attention in themselves, it must be kept in mind that they are relevant in the present connection only because they tend to show that the retardation which appeared following the first year was in all likelihood due not to the experiment but to some organic deficiency

Discussion

It seems to us that the experiment shows that normal behavioral development can occur in some infants when most of the first year is spent under conditions of minimum social stimulation and of very restricted practice. In other words, a large number of acts on the part of the adult which have been held by some people to be of importance may be dispensed with Fondling is not necessary for the development of interest in, and every sign of affection for, the adult The child does not need more than the barest materials in order to achieve the development shown by the chart Furthermore, he need

not be carefully watched for the proper administration of rewards and punishments. The infant within the first year will "grow up" of his own accord.

Summary

Two infants reared under conditions of minimum social stimulation and restricted practice for the first seven lunar months of life, and under less stringent conditions during the remainder of the first year, yielded during most of the first year a record of development not distinguishable from comparison records of infants in normal environments. Retardations in the onset of certain responses are believed to have been due to specific restrictions of motor practice. No general retardation appeared in one subject. The general retardation of the other subject from 10 months of age onward is referable to an intracranial birth injury and not to the experiment.

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CONTRASTS IN MARITAL RELATIONSHIPS IMPINGING ON CHILD ADJUSTMENT: TWO CASES*[1]

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The first case is that of a small boy, *W.*, at times tense, at times overly-excited, often withdrawing from response to others yet overly aggressive, vindictive, unstable, and, as it were, out of harmony with himself and the world. The second case, again, of a small boy, alert, full of vitality, eagerly confronting situations before him, relishing play materials and other children, and, on the whole, orienting himself with stability in his day to day life.

Both children attended the same preschool,[2] and were observed by the same investigator in a research project covering 33 cases in which child adjustment was studied in connection with tensions in the interparental relationships.[3] Both children came from well educated families of the same occupational level. The parents of both would have been said by any casual observer to have been functioning as harmoniously with each other as the "average" couple. In interviews, however, the father and mother of one child uncovered tensions in various areas of their marriage, which from the equally frank reports of the other father and mother, appeared to be absent. Both children evidenced behavior problems of one sort or another. Yet, when each was rated on an adjustment scale by head teacher and investigator separately, the average adjustment status obtained was for the one, poor adjustment, for the other, satisfactory.[4]

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[1]From a paper read at a meeting of the Pacific Coast Association for Nursery Education, Southern Section, May 8, 1937.

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[3]A Study of Reported Tension in Interparental Relationships as Coexistant with Behavior Adjustment in Young Children (Doctoral Dissertation, Claremont College, April, 1937).

[4]Further details concerning this scale and other points brought out in the study are given in an article based on the above study, and bearing similar title, appearing in the Journal of Experimental Education, December, 1937.

What, then, were the marital tensions entering in the case of one and absent in the other? And which were tensions of the sort more typically associated with poor child adjustment in the entire group of 33 cases included in the study in which these two were part?

Let us first present the case studies and then comment on the various sorts of marital tensions which appear in them in the light of whether these same sorts of tension were significantly[5] related to child adjustment in the whole 33 cases studied

CASE ONE *W G*

1 *Identifying and General Physical and Psychometric Data*

Age at entrance to preschool Two years, five months
Age at close of case Four years, six months
Average adjustment status during progress of case Poor

a Health.

Health and developmental history showed no marked deviations from the average.[6]

In the repeated pediatric checks *W*'s health was considered good He appeared to be well nourished There was a slight convergence of the eyes A tendency persisted to chronic redness of mucous membrane of larynx and nose

In the orthopedic checks general posture was shown to be good Spine and feet normal Slightly protruding abdomen One inch knock-kneed

Weight was consistently slightly above average for height, and height slightly under average for age throughout the school career

b Psychometric (Stanford Revision of the Binet-Simon Scale)

C A 4 years, 5 months, *M A* 5 years; *I Q* 113 (Previous attempted tests were considered non-diagnostic because of the child's negativism. For the same reason the results of this testing were likewise questioned)

c Speech checks

Periodic examinations during the school career by the speech specialist were essayed In none was it possible adequately to check enunciation as the child was extremely negative A pronounced stutter was, however, noticeable

2 *Summary of Observational Records in the Preschool and of Reports on Child's Behavior from Home*

[5]The term significant as used throughout this paper carries the usual statistical designation, here specifically meaning whether the difference in proportion of child adjustment in cases where a tension was present and in cases where absent equalled three or more times the standard error of the difference (of the two proportions)

[6]The question of a post-encephalitic condition was gone into because of the child's instability, but was out-ruled in the light of the complete medical history

a Motor development.

On entrance *W*'s movements were somewhat stiff He manifested poor control on the apparatus and was clumsy in use of materials and awkward in the handling of clothes, etc All motor coordinations showed great improvement by the close of the case The left hand was definitely preferred

b Intellectual development

Flightiness and quickly shifting attention were noticeable For example, he would start out for an airplane, saying, "I want that airplane," and on the way catch sight of the swing, go toward the swing, catch sight of a tricycle, rush toward it, stumble over a ball, and shift quickly to focus on the ball

He would ask innumerable questions but would not appear to attend to answers, instead going on with his own stream of talk, either repeating the question or explosively demanding, "*hwat?*" ("What?") five or six times over, not waiting in between for reply

Most pronounced interests were in hammer and saw

c Social development

W played by himself a good deal, however, toward the latter part of his school career playing more with other children In contacts with them he had no regard for priority rights He would push them from tricycle or kiddie car as he wished these for himself

He was openly and aggressively antagonistic to other children, hitting them with no obvious provocation, pinching, kicking, squeezing, choking, poking them with sticks, and so on

In addition he would often talk about biting others, "chopping them up," and the like, and would dramatize various sorts of "killing" as, for example, going around the yard with a piece of clay repeating that he had it for the purpose of "shocking people dead" He would frequently threaten, as for instance, to another child,

"Someday I'm going to bring a gun and kill you
And shoot you dead,
And then I'll cut your head off with a knife
And then I'll cut everything else off and let the God out of you
I'll bring everything for the business
And you'll be dead and all cut up"

He demanded much attention from adults in his play, appealing to them for help rather than attempting to solve his own problems, and often, asking them for suggestions, only to continue on his own way He also frequently demanded that they "Look, look," at what he was about, and, as has been mentioned above, came to them with many questions, not apparently seeking information, but rather contact

d Emotional adjustment

Early in his school career, tallying with reports from home, there appeared to be a shutting out of everything but his immediate (usually quickly shifting) goal, with no regard for any child, material, or rule in

the way. He would shove all aside and go straight toward his own end For instance, coming into the rest room one day, he saw the "turtle bowl" on a shelf and started toward it The teacher told him it was time for rest, not for watching the turtles He gave no evidence of hearing, but continued toward the bowl, knocking over a chair in his way, which he apparently failed to notice as being there Later this imperviousness was replaced at times by either direct negativism or by evasiveness, as saying he "did not know how" to carry through simple requests, etc

Meal times were periods for displaying varied emotional manifestations There were many food refusals, much spilling of food, crying, breaking of dishes, and so on

Crying and whining at other times were also much in evidence He would meet defeat with either this sort of response or with more violent temper. A tricycle spill would for instance bring forth from him a veritable torrent of abuse, shrieks and kickings, and sobs of "I'm mad at you" Temper tantrums were especially prevalent when the child was with his father

Jealousy of two younger siblings was shown by open avowals of "I don't like them," by jamming of fingers in doors, by attempts to choke, or otherwise injure them.

Cruelty to animals was also evidenced, culminating in the crushing to death of a baby duck

That a pronounced stutter existed has already been mentioned

Frequent masturbation would take place, either after defeat, or during periods of aimless wandering

On the whole the child was at odds with himself—unstable—varying *from periods of tenseness to periods of irritability and excitement*

e Summary listing of problem behavior evidenced

Feeding difficulties
Temper
Crying and general irritability
Imperviousness
Negativism
Failure to regard others' priority rights
Antagonism, meanness, cruelty to other children.
Jealousy of siblings
Flightiness
Over-demanding of attention from adults.
Masturbation.
Stutter
Cruelty to animals.
General instability

3 *Significant Factors in the Social History and Summary of Parental Interrelationships.*

The father and mother were both college graduates, the father a salesman of stocks and bonds. He was a tall, thin, slightly stooped man whose movements were somewhat jerky. He always appeared to be rushed and spoke with rapidity, repeating many phrases several

times and occasionally hesitating on initial vowel sounds, giving the impression not so much of a stutter as of nervousness He seemed very tense and self-conscious.

The mother was a large handsome woman with a rather tense manner that she obviously tried to control, so that she possessed what appeared to be an external quiet and calm. When she forgot this, as she would at times in conference, she would talk with much greater speed and with rising voice She gave the impression of being capable and efficient, strong and resolute

The father in his own family had been dominated by parents and four older sisters He was the baby and the only boy Domination was alternated with pampering He wanted to take more and more responsibility for himself as he grew but would always find himself being told what to do or having things done for him He came to feel in consequence increasingly inadequate He longed for a boy of his own age to talk to but was always unable to find the perfect companion with whom he could talk and share difficulties His parents lacked harmony. He was extremely antagonistic to both of them His one source of consolation lay in the sympathy and kindness which he felt came unceasingly from his one sister This sister he brought to live with the mother and himself when they were married.

The maternal grandfather was a harsh, severe man, oppressive to the maternal grandmother. On the farm on which they lived the grandfather "forced" the grandmother to do work that was too heavy and too hard for any woman The mother resented his treatment of her mother and his domination of both grandmother and herself, yet she felt guilty over this resentment and repressed the antagonism (which in the course of conferences with the worker she was able to bring out and clearly face) She knew, however, that she craved independence and that she longed for the day when she could be her "own boss," stand on her own and move from home.

Thus the father entered marriage, having been pampered and dominated and having gained a feeling of inferiority from these Whereas the mother had been much dominated, likewise having gained a sense of inferiority

The father wanted a son above everything After *W* came, the

mother began to identify him with her father, seeing in the two several pronounced resemblances, rejecting the child in consequence On their arrival, she turned to the girls, giving over the care of the boy to the father. The father slept with him, bathed and dressed him, and disciplined him in his own fashion Boys needed to be strong in character Sternness hardened them . Every opportunity to exact obedience was utilized Here was an outlet for the father's earlier-born need for adequacy

Not that he had failed to seek other outlets He had worked hard at his job, but "the cards were against him—the depression" According to him, it had been a hard pull He would get upset and that would upset the mother and make her irritable with him It had jarred his confidence in himself. He knew his upset condition had reflected on his wife The money end too had been bad He would get more upset and would be apt again to upset the mother

He felt he should be boss of the family But the mother resented this. According to her own account, "I'm not a bossy woman but I want to take the leadership." Her husband wanted to be the man of the family, and she was not willing to pass the status over to him There was "something in her" that detested being dominated. The same in the father As the result? Trouble. . "No, they never can talk things over. The father likes to argue and argue, and it's always argument and never talking things over. It drives her crazy . . "

Conflict entered on the score of friends and leisure pursuits Moreover, one would criticize at every opportunity and the other would resent the criticism. The father longed for some other sort of response, for sympathy and consideration and understanding instead He resented the lack of these in his wife Also her lack of affection This latter, however, the mother felt she needed definitely to withhold, because when she became the least bit loving, the father would "take advantage" of her and "force himself" on her seeking sexual relations A purer sort of affection she longed for, but not for the sexual part of marriage, which was distinctly objectionable to her, unpleasurable and unsatisfying She had heard that other women reached a climax, but she herself, never . . Having the father sleep in another room with the child helped a little . . .

But here arose another sort of conflict. She had turned *W* over to the father, and what sort of a child was *W* becoming? Stubborn, tempestuous, cruel! She could see that the father was too exacting and strict She felt that the child was rebelling Disagreements over the child's up-bringing grew.

And yet another source of conflict The father's sister "After we were married, she used to come in at night and sit on the edge of the bed to talk to him You know the atmosphere that exists because of my feeling toward her and her jealousy of me is perfectly terrible " and again, "He is her husband-substitute. He means just everything in life to her But he wasn't satisfied with just having a sister, that's why he married me But even so I just give him half the things and she gives him the other half I'm just half a wife and she's the other half and I feel "extra" [7]

Case Two HB

1 *Identifying and general physical and psychometric data*

Age at entrance to preschool Three years, four months
Age at close of case Three years, eight months
Average adjustment status during progress of case Satisfactory

a *Health*

Health history and developmental history normal According to the pediatrician's check, health at the time of preschool attendance was good, nutrition good No defects
In the orthopedist's check, posture was termed good Slight knock-knees Prescription for Thomas heel given
Weight was above average for height, and height average for age

b *Psychometric* (Stanford Revision)

CA, 3 years, 8 months, *MA*, 6 years, 2 months, *IQ*, 175

c *Speech check*

Score 42 out of a possible maximum enunciation score of 47 Child substituted *b* for *v*, *d* for *the*, *z* for *zh*, *s* or *f* for *the*, and *w* for *wh*

2 *Summary of Observation Records in the Preschool and of Reports on Child's Behavior from Home*

[7]The summary above, as well as that in the next case, is based on information which was gained not through questionnaire but in informal conferences in which the interviewee was given much freedom to talk—the points investigated being gotten at more often through indirect suggestion than through direct questioning—comparable items, however, being covered in all cases included in the study

a Motor development

Excellent motor coordination was manifested both in large and small muscle control *H* used all apparatus with a great deal of vigor, putting them often to dramatic use, as having the balancing boards be bridges, etc, which often entailed "tricks" calling for skilled coordinations Clothes were easily manipulated The right hand was preferred.

b. Intellectual development

At first in the school situation, *H* ran from one thing to another without concentration, rushing around in investigatory persuits By the end of the semester, he had settled down to longer periods at an activity, showing a fine ability to work toward ends, to solve problems, and to meet difficulties

He spoke freely to everyone, making himself understood in spite of the infantility in his enunciation In his questions, he showed an alive curiosity concerning phenomena about

He investigated and explored the environment He utilized equipment, boxes, blocks, and boards to construct with and as props in his dramatizations The tricycle might, for instance, be an airplane with boards across the hands for wings, or a box might be a house with blocks built in it for stove, ash can, and so on

Special interests were in the animals, in stories, music, paints, and blocks

c Social adjustment

The mother on entrance reported from home that the child grabbed things from his older sister This cleared, however, by the end of the semester as the child gained more adequate concepts of "give and take" in the school situation with his peers In school he worked and played with the other children, with very little conflict, although he was always positive and determined in defending any rights that were imposed upon Leadership was evidenced frequently He would start dramatizations, constructions and the like

He would often volunteer to help wash dishes, feed the animals and help the younger children lace shoes, etc

d Emotional adjustment

The mother reported a fear of dogs and shyness in his meeting of strangers at home On entrance he clung somewhat to his mother and cried from fifteen minutes to half an hour during his first three days at school, after which the crying disappeared When the mother spent her observation morning in the school (once every four weeks) he did not cling to her or notice her unduly, but went about his activities with his usual relish.

On the whole he presented a picture of an emotionally well-balanced, stable person

e Summary listing of problem behavior evidenced.

Temporary failure at home to regard sisters' priority rights
Distractibility on entrance to school
Fear of dogs

Shyness on meeting people
Crying for and clinging to mother on first entering school
Infantilities in speech

3 *Significant Factors in the Social History and Summary of Parental Interrelationships*

The father was a bond salesman, the mother a teacher The father gave the appearance of an ex-football player—tall, athletic, and clean-looking He had a quiet and pleasant manner.

The mother was plain but wholesome-looking When she smiled, her irregular features would light up so that one would forget her homeliness She, like the father, looked as though she enjoyed athletics and outdoor pursuits Her manner was comfortable, free, and outgoing.

The sister, older by four years, was an exceptionally brilliant and capable girl with marked artistic talent that won much admiration from her parents.

The father was the oldest in a family of seven children He had been much dominated by his parents They had demanded that he be "just right" As the father stated, "It had not been possible to live up to their demands" He was constantly being blamed for not doing things properly. Combined with this, the paternal grandparents believed that they should "map out" their childrens' lives They decided the college he should attend much against his will. When the war came he enlisted as a protest against them, a way of gaining independence But the new independence was fraught with difficulties He found it hard to depend on himself after having had the sort of childhood and adolescence where responsibility had been so much taken from him He found himself feeling inferior, inadequate, and lacking in self-confidence.

After the war he started to work and did fairly well, yet could not feel that his work was very important Finally he met the mother and found in her a sympathetic, comfortable sort of person. Possibly because of her very homeliness, he could feel more adequate with her.

The mother had been next to the oldest in a large family The maternal grandmother was a "nervous person" and "bothered more about herself than about her children" She and the maternal grandfather were apparently harmonious in their relationship to

each other, and although the children were not neglected, yet they were left to come and go rather freely as they wished, with few demands and little pressure

The mother worked her way through high school and through her teacher training. She entered into school activities and sports of all sorts and felt capable and adequate and happy in her own independence

If she felt any consciousness of her lack of looks, she never expressed this to the worker She seemed to have set value on lines where she could achieve Having been brought up in a family with limited means, she was glad to get along with what the father provided She and the father found in each other similar tastes, they liked outdoor sports and "nature" and enjoyed mutual friends

Neither was felt to be ascendant by the other Rather they felt that they had cooperative working arrangements, that they could talk things over and see things through by mutual assent Both were interested in the children and cooperated jointly in point of view and action in their upbringing.

Sexually they were well-adjusted The mother achieved orgasm regularly In conferences the father wanted further information on one aspect of their sexual relations He wondered if he were possibly "too fast" for the mother, as he needed usually to satisfy her after ejaculation had occurred, and desired information as to whether there were preferable techniques of handling the situation than those he was utilizing She, however, reacted to the latter without qualms, freely responding and feeling perfectly satisfied, more relaxed, and closer after coitus. So that all in all, both partners were finding satisfaction

Neither was critical of the other but gave to each other an understanding sympathy that each relished. When either was upset they shared the difficulty with the other As for consideration, neither were, as the mother expressed it, "sticklers as far as attentiveness was concerned" It didn't matter if they didn't have presents on formal occasions. What meant more were little signs of affection "at just any time" The father might bring her a book as he had money, or pick a few flowers from the roadside The mother had been delicate at one period of their married life, but rather than this having made for conflict, it had, she thought, brought

them closer together as the father had been "so grand" to her, taking care of her almost as though she had been a child.

Thus, from their quite frank accounts given in conferences, not any particular areas of tension were in evidence in their relationship with each other

What then were the items of tension which were present in the marital relationships of the parents in the first case and absent in the second? Briefly they were.

Tension over sex
Tension over the ascendance-submission relationship
Tension over lack of consideration, sympathy and the like
Lack of cooperation on the upbringing of the child
Inability to talk over differences to mutually acceptable solutions
Tension over the expression of affection.
Tension over friends
Tension over work
Tension over relatives
Tension over leisure pursuits
Tension over criticalness of the mate
Tension over finances

These tensions were operative in the environment of the first child and not so in that of the second Obviously other factors were also present which could have made for increased strain in either environment, as, in the first case, the child's displacement by two younger sisters, as in the second case, the greater focus of the parents on the older sister and her artistic talent. One cannot definitely say These marital tensions produced this maladjustment in the child All one can say is that certain marital tensions in all probability played their rôle, either as primary causal factors, or as contributing factors, in the child's maladjustment, since in the 33 cases studied, taken as a whole, poor child adjustment was appreciably greater in cases where certain sorts of tension were present

Tension in the area of the parents' sexual relationships appeared as a factor of paramount importance Tension on this point existed in 22 out of the 33 cases In the 22 cases where it existed, only two of the children were well adjusted That is, 91 per cent of the children were poorly adjusted Conversely, in the cases where sexual

adjustment was satisfying to both partners, all but one child was satisfactorily adjusted That is, 91 per cent satisfactory child adjustment in cases where sex tension did not enter, in contrast to the equally large proportion of those poorly adjusted where such tension did enter.

Tension in the area of ascendance-submission appeared as well to be particularly important in connection with child adjustment Significantly related also were the remaining tensions listed above with the exception of the last three In addition, there were two other items which do not appear in the above cases, but which were on the whole significantly related to child adjustment These were tension over health, and extra-marital affairs Moreover, one other item which does not appear above—namely, tension over tastes—was not significantly related to child adjustment

It will have been noted in comparing the two foregoing cases, that certain factors from the background of each parent in each case seemed to carry their weight into the present For instance, in the first case the father had in his earlier family life felt inferior and inadequate In the second case the father similarly had felt inferior and inadequate. Both came into marriage carrying needs for achieving greater self-regard How were these needs met by the partner? In the first case the mother, having resented earlier domination, *having craved independence, met what no doubt appeared as a* threat to her independence by renewed resentment and a compensatory "stiffening of the back," making the father feel again inadequate In the second case, the mother, having achieved an acceptance of self as a capable person, apparently did not feel that giving herself fully to another was in any way a threat to her status Hence with her the father could feel acceptable, comfortable, at ease, and more self-confident. He did not have to struggle for superior status through domination

In similar ways in many of the other cases, needs carried over from earlier days were projected into compensatory strivings in the marriage, into seeking satisfactions for earlier lacks in ways that either fitted together in a pattern fraught with conflict or into one more harmoniously wrought Nor did unsatisfied strivings arising from earlier needs seem to end in the relationship of one partner to the other Rather they seemed to run through the relationship

of partner to partner—as a current along a wire—and pass on into the life of the child How much would the father in the *G* case, for instance, have persisted in projecting his need to dominate onto *W* had he felt adequate in his relationship to *W*'s mother?

Whatever the answer, one point of interpretation and one question, arising out of the material here presented, seem in order

(*a*) The child in the case does not apparently have to witness overt conflict for an item of parental discord to impinge on his adjustment Refer back the figures cited above on the coexistence of child maladjustment with parental tensions in the area of sex Certainly no child bore actual witness to sexual conflict, yet apparently its existence did dynamically impinge on his development

(*b*) If tensions in the marital relationships of parents do coexist significantly with child adjustment, as certain ones did in the present investigation, then in our growing field of Parent Education would we not do well to stress "parent-parent" relationships equally or even more, than the "parent-child" relationships which have come in for so much concern in recent years? And would this then not mean some leavening of absorption on Johnny and his problems, and how-can-mother-be-calm-wise-and-objective-in-relation-to-them? And would it not bring a balance of emphasis on parents themselves, and on their needs as people seeking love, response, and harmony with another human, as perhaps the greatest of all needs in their lives?

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ORDINAL POSITION AND ITS RELATIONSHIP TO SOME ASPECTS OF PERSONALITY*

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The importance of ordinal position within the family has, within recent years, become a subject of serious psychological investigation. Many influences have contributed to this renaissance, including psychoanalysis which has played an important rôle. Predisposition to mental disorders has been regarded as related in some way to ordinal position, and the psychoanalytical schools of thought, emphasizing as they do the rôle of the familial situation in neurosis, consider position within the family (with its psychological implications) as being significantly related to neurosis. Unfortunately this conclusion is based largely upon clinical observations with little if any controlled experimentation. Thus Hug-Hellmuth (32), in 1921, was of the opinion that it is the *middle* of three children of the same sex differing little in age which feels most painfully the uncertainty of its position at home, and Adler (1), in 1928, went further in stating that because of the home situation pointed out by Hug-Hellmuth middle children are most predisposed to neurosis according to his clinical observations, although other positions are not free from neurosis.

That this outlook is heavily subscribed to may be judged from the statement of Blatz and Bott (6) that

> Almost everyone engaged upon clinical work in the field of delinquency will confess that, whether justified or not, there exists a tendency to emphasize the importance of the position within the family of a case presented for discussion. Generalities and impressions, lay and professional, are manifold with reference to the "only child," the "only son," the "large family," etc., and upon the significance to be attached to such relationships. . . . The perplexities encountered when one attempts to examine such claims or to gauge the factors that must be taken into account become more subtle and elusive as one proceeds in the analysis.

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A review of previous experimentation in this field is, therefore, essential.

The differential effect of birth order has been manifest for thousands of years in the selection of heirs, kingships, priesthoods, and the like. Whether or not this selection was dominated by the belief in the superiority of the first-born cannot be answered at this time. It was not, however, until 1864 that this problem was first subjected to scientific investigation In that year Duncan (31*c*), as reported by Hsiao, published a report demonstrating that at birth first children were inferior in weight to subsequent born children. He found that first children averaged 7.17 pounds in weight and 19 2 inches in length, while all other children averaged 7.27 pounds in weight and 19 2 inches in length Hsiao (31) reported that this conclusion was subsequently confirmed by the findings of Hecker (31*e*) in 1865, Issmer (31*f*) in 1887, Schmid (31*h*) in 1892 and Hansen (31*d*) in 1913 Boas (7), in 1895, demonstrated that this superiority applied to height as well as weight at birth

It was natural that Duncan's work should act as an impetus to investigation of physical differences because these differences lend themselves with ease to accurate measurement. Studies were published in rapid succession ranging from investigation of skeletal conditions to susceptibility to various diseases. Thus Cadré (31*b*) in 1910 reported that after studying 203 infants ranging from a few hours to not over nine days, he found that the overlapping of the sagital suture, due presumably to compression during delivery, was most frequent in first-born Rivers (53), Pearson (48) and Hansen (31*d*), working independently at about the same time, came to the conclusion that there is a heavy incidence of pulmonary tuberculosis in the first and second born, which incidence is far greater than it should be if the order of sibs was of no significance Studies of other diseases are too few to be conclusive Rivers (54) study of deaths due to cancer, for example, indicated a slight excess of incidence on the first-born, and Pearson's (50) study of albinism indicated that there is a marked excess among the first-born, no excess among the second-born, and that there seems to be a defect among the last-born

Still another approach has been through the analysis of vital statistics. By this means mortality and longevity as related to ordinal position were investigated as early as 1874 The first surprising

fact uncovered by Ansell (31*a*), as reported by Hsiao, was that still-born first children greatly exceeded all the other classes, the proportion of dead to living first-born being more than double the average of all other classes This finding was subsequently confirmed from new data by Pearson (50) 40 years later Ansell further showed that although mortality among first-born children was much greater than in other classes during the first week of life, after that period it fell below average for several years, and at most ages up to the end of the sixth year, the first-born children showed the most favorable mortality of all

	1st	2nd	3rd	4th 5th 6th	7th
Survivors out of 1000 reaching age 15	836	845	847	835	813
Survivors out of 1000 reaching age 45	658	653	655	654	635

Beeton and Pearson (4) in 1901, from a study of more than 1000 pairs of siblings, also found that longevity is correlated with position in the family and, on the whole, the earlier-born members are fitted to survive longer, thus supporting Ansell's conclusions

The problem of physical differences as related to order of birth has not been exhausted, although the last 20 years has shown a temporary neglect of this important problem Suggestive beginnings along several lines were made two decades ago but have not been followed up and await crucial experimentation before they may be considered conclusive. For example, Chase's study (14) in 1914 indicated that eldest sons were the weakest on tests of strength, studies have been made of pneumonia (34), epilepsy (70), congenital cataract (50) and cancer (54), without arriving at any conclusions. This defect in attention was, in the main, due to the swing of interests to problems of a testing nature, following the introduction of the testing techniques of Binet and the subsequent revisions The growth of interest in testing and the World War successfully dominated the sphere of psychological thinking, and interest in the problem of ordinal position in the family did not have a renaissance until the early '20's The revival of interest in this problem clearly showed the effects of the preceding decade Whereas previously the avenues of inquiry had been dominated by physical considerations, interest was now psychologically oriented. The development of the

testing technique for psychological traits offered investigators the tools, for the first time, with which experimentation could be prosecuted in the realm of the mental as opposed to the preceding studies in disease, mortality, muscular strength, and the like.

It is not absolutely accurate to say that the problem of the relationship of ordinal position to various psychological traits was not investigated until the 1920's because there were several excellent beginnings as early as the 1870's I have in mind, in particular, Galton's study in 1874, Yoder's in 1894, Bohannon's in 1898, and Gini's in 1915 These studies, however, were handicapped by inadequate criteria, and thus were compelled to utilize "success" as the main criterion Thus Galton's study (23) of English men of science showed that elder sons appeared twice as often as younger sons, and intermediate sons contributed equally Yoder's study (74) of eminent men of various nationalities of the 18th and 19th centuries supported Galton's results in that he, too, found that eldest sons were represented more often than youngest, who were more often represented than intermediate ones Gini's (24) study of professors in Italian universities showing that first-born predominated is, of course, in agreement with the findings of Galton and Yoder

Bohannon's (8) work, under the direction of G. Stanley Hall, *introduced an innovation in the form of the questionnaire method*, and from a study of 381 cases he concluded that *only* children are unusually predisposed to mental disorder, a conclusion to which Brill, Coriat, Putnam, and Wexberg subscribe on the basis of clinical experience Mitchell's (31g) study of 443 idiots showed that youngest and especially eldest born largely predominated over the intermediate children, which conclusion is subscribed to by Ellis (18) and Pearson The 1907 study of Heron (28) of mental hospital inmates led him to conclude that *first-born* children from insane stock are more likely to become insane than other sibs, the observed frequency being 108 as compared to the chance expectancy of 77 3

With the general acceptance of the use of tests there was a revival of interest in this problem The intelligence test in particular became the most widely used tool in the investigation of ordinal position, but the results of many studies, unfortunately, have not been in agreement Most of the studies, namely those of Willis (72), Sutherland and Thomson (62), Goodenough and Leahy (25),

Kinser (35), Jones and Hsiao (34) and Korn (36), indicate that there is no relationship between *IQ* and ordinal position. Willis, in 1924, studied 219 pairs of first and second-born children and found a slight difference in favor of the second child, but when correction was made for age differences the results were nullified. Sutherland and Thomson, in 1926, studied 1084 children ranging from 10-6 to 11-6 in age. With size of family kept constant, correlations were computed between *IQ* and birth positions for families of 4, 5, 6 and 8 children. They found none of the coefficients differing reliably from zero. Hsiao's (31) study of 2127 children, in 1929, indicated that there were no reliable differences in intelligence between first- and second-born as measured by various intelligence tests. Other, more recent, studies found a direct relationship between *IQ* and birth position, namely those of Arthur (2) in 1926, Commins (15) in 1927, Thurstone and Jenkins, (66) in 1929, and Locke and Goldstein (38) in 1937. The last named, for example, made statistical analyses of the records of 1500 children in the Hebrew Orphan Asylum in New York City, and their results showed a consistent tendency (probabilities of significance ranging from 71 to 91 chances in 100) for the later born to be superior in intelligence. Thurstone and Jenkins reported, from a study of 382 pairs of siblings, that they found that the mean *IQ* for the first-born was 81.75, while that of the second was 84.84. No corrections, however, were made for age differences.

In disagreement with both of the above groups, Terman's (63) study, in 1925, of 754 gifted children, led him to conclude that gifted children were most frequently first-born in families of 2, 3, and 4, even when no corrections for age were made. Guilford and Worcester (27), from a study of 21 only children and 141 other children, concluded that only children are equal to or superior to the other children, in regard to school grades, "efficiency record" and intelligence, and either equal to or very slightly inferior to the non-only child in voluntary participation in extra-curricular activities. Hooker's (30) study in the following year led him to essentially the same conclusion. He used 30 only children paired, as closely as possible, with non-only children for grade, sex, age, nationality, and IQ, and by the use of a questionnaire and two rating scales concluded that only children are superior.

Two recent studies along the lines of those of Galton and Yoder

are those of Havelock Ellis (18) in 1926, and Cattell (13) in 1927. Ellis listed 1030 men and women who were recorded in the Dictionary of National Biography, and reported that he found that there is a special tendency for eldest and youngest children to be born with intellectual aptitudes, the liability being greater in the case of the eldest than in the youngest. Cattell, too, reports that an analysis of American men of science disclosed that the eldest was always more represented than the 2nd, 3rd and 4th, in families containing 2, 3, and 4 children. The only dissenting study of this type is that of Key who, in 1926, reported that a study of famous Americans from Alexander Hamilton to Mark Twain resulted in no correlation with birth position.

Studies in feeblemindedness as related to this problem go back as far as 1866 and Mitchell's study of idiocy, already mentioned. Shuttleworth's (31*t*) study of mongolian imbeciles, in 1900, indicated that 40 per cent were youngest children. In 1922 Tredgold (67) reported that it is more common for the later born to be affected, and that in those families in which there is a pronounced tendency to mental and physical degeneracy, the effect usually appears to be more and more marked upon each successive child, and often enough the idiot is actually the last born. Kuhlmann, as quoted by Arthur, on the other hand, from the data of Piper, Koenig and Kerlin, has purported to show that the incidence of feeblemindedness is the highest among the first-born and decreases for succeeding positions. In 1929, Dayton (16), from a study of 10,410 retarded children, tested by means of the Stanford Revision of the Binet-Simon, considering families of different sizes separately, reported that he found no evidence that the feebleminded child tended to be either the first or the last in the family.

We now come to a consideration of mental abnormality as related to the problem of ordinal position. The chief consideration is whether or not any particular birth position is correlated with the *predisposition* for mental abnormality, rather than whether or not there is any correlation of birth order with mental abnormality. The work of Bohannon and Heron has already been cited above. Reynolds (52) from a study of 400 consecutive cases referred to a behavior clinic, found that the number of *first-born* was greatly in excess of expectation.

> The only children afford a distinct contrast to the middle children in several respects In general attitude toward authority as indicated by reports of negativism, persistent disobedience in home or school, temper tantrums, etc, they show the highest percentage of positive reports Characteristics of this sort are reported for 71 per cent of the only children, as compared to 55 per cent of the oldest, 39 per cent of the middle and 56 per cent of the youngest (p 50)

The results of a study by Rosenow (55) of patients of child guidance clinics in several cities showed that the number of *first-born* among the patients, after statistical correction, was still exceedingly high. Levy's (43) report on 700 cases of problem children pointed out that *first-born* were greatly in excess of the chance expectation, and all other birth positions were less frequently represented In 1927 Foster (22), from a study of 50 cases of jealous children brought to a behavior clinic, reported that the *oldest* and *only* children were greatly in excess of expectation from a study of a control group.

Korn's (36) study of 12-year-old school children led her to report that, on the basis of her personal observations, the three groups she used, i.e , only, oldest, and middle children, were clearly demarcated as far as group behavior was concerned Using questionnaires (which is questionable procedure with 12-year-olds) she concluded that only and oldest children were less emotionally stable Yet her analysis of school records showed that only children were superior in work or proficiency, and only and oldest children were, on the whole, better in conduct and deportment. The inconsistencies of these two conclusions are not explained. Campbell (12) compared 100 only children with 100 middle children, selected from the college body, in relation to ratings of neuroticism, self-sufficiency, introversion, dominance, and irritability. On the whole, only children made higher scores on scales measuring neuroticism and introversion, and lower scores on ratings of self-sufficiency and dominance

These studies have been carried into the field of delinquency in recent years. Breckenridge and Abbott (9) found a preponderance of *oldest* children among 584 delinquent children referred to juvenile court, and Burt (12), making a similar study in London, found *only* children were greatly in excess of the theoretical expectation.

In contradiction of these studies is that made by Goodenough and Leahy (25) who reported that no relationship was observed from their studies of children referred to the behavior clinic, and that of Baker, Decker and Hill (3) who studied 84 convicted delinquent boys by comparison with a control group of normal boys matched as to age, grade, nationality and neighborhood. They reported that the birth position in the family was not a significant factor.

Stratton (60) touched upon the problem of ordinal position in a study of anger and fear. Using college students as subjects, and the technique of introspection, he found no difference between the first-born and others in respect to fear, but he found a reliable difference in respect to anger, indicating that first-born are more prone to anger than others. Goodenough (26) investigated the emotional behavior of 990 children, ranging from 18 months to 6 years, in a mental test situation and reported slight differences only in regard to distractibility.

A summary of the literature demonstrates that the problem of the rôle played by ordinal position has been approached by many avenues of inquiry in attempts at arriving at some definite conclusions. Unfortunately, except in some instances, there is general disagreement on practically every point. Agreement is highest in regard to physical data. Agreement is practically uniform that, at birth, weight varies directly with the order of birth, the first-born being the lightest. The evidence in regard to skeletal and muscular conditions, and susceptibility to certain diseases, although not conclusive, indicates that first-born are inferior and more susceptible, respectively, than subsequent-born. There is practically uniform agreement that there is a heavy incidence of still-born eldest children, which incidence is far beyond the normal expectation. Of those who survive, however, the earlier born members are fitted to survive longer.

There is wide disagreement regarding the relationship between intelligence and position in the family but, on the whole, agreement is good that superiority (i.e., talent) is correlated with birth position, using *success* as the criterion. The relationship of feeble-mindedness to birth position has not been, however, satisfactorily determined. A great deal of confusion exists regarding the rôle of birth position in mental abnormality, although the majority of opinion is that the first-born children are unusually predisposed

to mental disorder Notable exceptions to this opinion are Adler and Hug-Hellmuth who favor the middle child for the rôle of most predisposed. The opinion regarding delinquency is divided

The reasons for the agreement regarding the relationship of birth position in the family to certain physical traits is not difficult to determine Criteria are more easily set up and accurately defined than in the sphere of psychological traits Thus, for example, the criterion of weight at birth leaves no room for individual interpretation, there is no disagreement regarding the validity of the measure, i e, the scale, and so the data of various investigators can readily be compared. Disagreement of results, therefore, can be due only to the selection of the sample

In the measurement of psychological traits we have no such general agreement The criteria and validity of the measures are open to questioning, and thus when two studies disagree, the lack of agreement may be due not only to selection of sample, but also to differences in criteria and measures Several available studies, for example, have investigated the relationship of intelligence to ordinal position Yet each one has used a different measure of intelligence To what is the disagreement in results to be attributed? To sampling, measure, or both? Some of the studies have tested two and three children from the same family, and although it is common knowledge that age influences the score on the intelligence test, no corrections have been made for age differences Other studies have made statistical analyses of the children referred to behavior clinics, for example, and published results which are meaningless because they do not include any information regarding the normal expectation determined from an analysis of the population from which the sample is drawn. What conclusion can be drawn from a statement that 10 per cent of the referrals to a behavior clinic are only children unless it is contrasted with the fact that the normal population of children contains only 5 per cent of only children? The criterion of "success," for example, is frequently used Is ordinal position the only variable? Obviously not. What about the advantages given to first-born in the way of financial aid, opportunities for education, etc, which are so frequently not available for subsequent-born? Before an adequate study can be made these factors must be considered.

Purpose of Study, Selection of Sample, Measures Used

This study was designed to investigate the problem of the relationship of ordinal position with some psychological factors which have been demonstrated to be amenable to measurement. As has already been discussed, prior studies in this field have been weakened by choice of criteria and selection of sample, thus making interpretations difficult This study is aimed at overcoming these difficulties in so far as is possible.

Reviewing these difficulties briefly, the first was the problem of adequate criteria Up to 1920 *success* was the most widely accepted criterion of superiority even though many recognized its fundamental inadequacy. The lack of valid and reliable measures (i.e., tests) forced experimenters to utilize this criterion and such devices as the number of lines devoted to the individual in professional biographies as its measure In this manner superiority or competence was estimated and ordinal groups compared With the increasing popularity of intelligence tests this criterion was abandoned and attempts made at systematic comparisons based upon actual scores made on a standardized test Unfortunately the academic bias of the various investigators led to the use of many diverse measures of intelligence, instead of utilizing the best available, leading to results which were not directly comparable To avoid this difficulty the present study utilized the Stanford Revision of the Binet-Simon test because of its general acceptance as an adequate measure of intelligence, and the one considered most valid and reliable.

The second difficulty which this study attempts to overcome is the problem of selection of experimental sample. This study does not use two or more members of a family, i e , sibs, to make up the ordinal groups. Such selection, of necessity, must involve the problem of age differences and its relationship to the scale, and the writer feels that if age differences can be in some way obviated and corrections made unnecessary that some sources of error can be eliminated. In the study being presented the ordinal groups are composed of unrelated individuals of approximately the same age, instead of sibs of different ages. The assumption made is that if there is no restriction of sample the law of chance is operative and chance inequalities leveled out, thus making ordinal groups just as comparable as if the various members of the groups were both sibs and of the same age. The opportunity for artificial selective

factors operating is also reduced to a minimum, a factor which has entered into previous experiments in that the experimental group was too frequently not representative of the normal population. The samples were taken from juvenile courts, behavior clinics, orphan asylums and the like, and it is conceivable that many of the differences in conclusions regarding the influence of ordinal position are, in reality, attributable to the sample used. The use of atypical samples introduces many uncontrollable factors, and it is for this reason that this study utilizes a "normal" sample, all approximately the same age, found in the school room rather than in the clinic or court or orphan asylum.

The selection of subjects for this study was made as follows: the 6 *B* and 6 *A* classes of Public School 91, Bronx, New York, comprised the experimental sample. Of the 6 *B* students all children were included in this study who satisfied the experimental requirements. These requirements were, first, that both parents should be alive and living at home, second, that no deaths have occurred in the family (and thus affecting the ordinal position of the subject), and, third, that other children in the family are not more than seven years younger or older than the subject. Out of a possible 140 enrolled in the 6 *B* group 103 children satisfied these requirements. Of the 6 *A* students, 10 children from each of the four classes were selected at random who satisfied the experimental requirements, thus forming a group of 40 subjects. None of the children used were related as sister or brother. No selection was used except the satisfying of the experimental requirements outlined above. Neither the teachers nor the children were aware of the purpose of the study or the measures being utilized. Only the principal of the school knew that the experimenter was not a member of the staff of the Board of Education, and that the testing program was not routine. The cooperation of the teachers and students were thereby ensured and personal considerations eliminated.

We will employ two methods of grouping the subjects. The first method is the historically accepted one of grouping into Only, Oldest, Youngest, and Middle. The second method separates the subjects into only two groups depending upon whether or not the subject is a first-born. These two groups will be denoted as First-born and Subsequent-born. This study is aimed at investigating the problem of ordinal position by taking a normal group of children, measuring

their performances on various standardized tests, grouping them according to ordinal position, comparing the various ordinal positions with each other and noting differences in performance, if any, among the several groups To accomplish this end a battery of tests was selected which is considered suitable for measuring the performance of children ranging in age from 10 to 13 years

The first measure selected was the Stanford Revision of the Binet-Simon test because it is well adapted for use with school children Since digit spans are an integral part of this test, auditory-vocal forward and reverse digit spans were also measured In the treatment of the results the writer has dealt with the number spans as separate and distinct from the *IQ* because of the disagreement prevalent (10, p 196) regarding the age placement set by Terman in his revision of the Binet-Simon scale

The Whipple-Healy tapping test was selected as a measure of motor ability because of the simplicity of material involved, the short period of time required for its administration, and because of its reliability (44, p 38).

To fit the particular needs of this study two arithmetic addition schedules *A* and *B* were constructed, using the material of the Courtis *Arithmetic Test, No 7.* These schedules were not intended to take the place of the Courtis Test as a measure comparing the performance of the individual to group norms, but rather to make possible the comparison of the individual's performance at two different times. Since the arithmetic problems of the Courtis test were originally selected on the basis of equal difficulty, it was a simple matter to select each even item to make up Schedule *A*, and each odd item to make up Schedule *B*. In the actual administration of these tests Schedules *A* and *B* were alternated with each subject to rule out any possible inequality which might still be present.

Finally, the last test in the battery of tests used in this study was the Morgan and Hull *Persistence Maze* (43) This maze has several possible solutions of varying difficulty depending upon the combinations of alleys which the experimenter wishes to use. The maze can also be so controlled that no solution is possible The subject is permitted to solve the various possible problems, thus building up a mental attitude that each problem presented can be solved Then the problem for which there is no solution is presented and the reactions of the subject are observed and rated on a

nine-point scale of persistence Morgan defines Persistence as

> a mental attitude which arises as the result of a definite environmental situation The stimulus to persistence is some situation that would tend to hinder the free unfolding of a course either begun or planned by an individual and the attitude of persistence indicates a reaction of pugnacity toward this thwarting situation This attitude is probably a conditioned response It might be defined as that attitude which drives a person, once he has underaken a task, to complete it to his satisfaction (43, p 180)

Morgan and Hull devised this maze situation to satisfy the conditions required to measure this trait from an analysis of the trait of Persistence and its development The conditions which must be met if an individual's persistence is to be measured are, according to Morgan and Hull, first, a feeling of familiarity with the task involved, since the subject has no means of evaluating the difficulty of a totally unfamiliar task Second,

> he must have experienced some success in the task Persistence is an outgrowth of the habit of success Hence it is absolutely essential that the individual experience success in the type of work involved in the test in order to measure how strenuously he reacts against thwarting in the same sort of work Third, training in success should involve the overcoming of increasingly greater difficulties Fourth, the final test must be difficult enough to thwart the most persistent person Fifth, there must be some scale by means of which the varying reactions may be evaluated Most of our test measures are in terms of degrees of achievement or the time taken to attain the same degree of achievement Since persistence is only indicated by the subject's reaction when achievement is withheld it is obvious that the first cannot be used in a test of this sort. In a previous experiment with the same apparatus, time was used as a measure, but seemed inadequate (43, p 182)

The maze was constructed according to the plan described by Morgan and Hull (43, p. 182) The paths were grooves cut in brass and mounted on an aluminum sheet

> The places marked *A*, *B* and *C* on the maze were holes so that when the subject, tracing through the maze with a stylus, came to one of these holes his stylus would drop into the hole

> During the test the maze is kept covered with a shield through which the stylus is inserted. Enough of the maze is visible around the stylus to indicate the nature of the turning places but not enough to enable him to see from one alley to any adjoining alley He knows when he has solved any particular problem by the fact that his stylus drops into a hole

The problems of varying difficulty were accomplished by inserting blocks in different alleys, thus cutting off parts of the maze

> The problems used were as follows:
>
> 1 A block as indicated by the dotted lines is inserted at point marked (1) on the diagram This cuts off the greater part of the maze and the solution of this one is very easy Hole *A* is open
>
> 2 Blocks are inserted at the two places marked (2) Somewhat less of the maze is closed Hole *A* is closed and a solution means finding *B* This is then a new problem with a different and more difficult solution than the first problem.
>
> 3. Blocks are inserted at the three places marked (3) The holes *A* and *B* are both cut off and a solution involves more tracing and the location of a new hole, *C*
>
> 4 Blocks are inserted at the three places marked (4) These three blocks cut off all three holes, *A*, *B* and *C* The solution of the maze is impossible

Procedure

The testing program was divided into three periods, several days apart. They included.

1. *Determination of Eligibility* Each child was first interviewed to determine whether or not he (or she) satisfied the experimental requirements If the requirements were satisfied a note was made against his name on the class roll so that he would again be called At this time the child was asked for parental preference, if any

2. *Determination of IQ and Number Spans.* In the second period all the children who were eligible were tested by means of the Stanford Revision of the Binet-Simon Scale, and also were tested for auditory-vocal forward and reverse digit spans

3. *Other Measures.* In this period there were seven steps, always given in the same order:

a *Arithmetic Schedule A* (*or B*), requiring 8 minutes The subject was given the following instructions

> You will be given eight minutes to find the answers to as many of these addition examples as possible Write the answers on this paper directly underneath the examples You are not expected to be able to do them all You will be marked for both speed and accuracy, but it is more important to have your answers right than to try a great many examples.

Tests were scored on the basis of number of examples added correctly.

b *Whipple-Healy Tapping Test* requiring 30 seconds The instructions were

> Tap one tap with pencil point in each square Start at bottom left-hand corner and go across to end of first row On second row tap from right to left and on third from left to right Keep on going back and forth as rapidly as you can One tap in each block Begin when given signal "Go," stop immediately on word "*STOP*"

The Whipple-Healy method of scoring was used

c *Whipple-Healy Tapping Test* requiring 30 seconds repeated with the instructions "See if you can do any better"

d *Morgan and Hull Persistence Maze* The subject was prepared for this test by the experimenter in the following manner. the subject was asked "Have you ever seen a maze?" Regardless of the answer the subject was shown one of the mazes used in the Porteus *Maze Scale* All subjects were familiar with such mazes from the puzzle sections of the comics Then the subject stood in a comfortable position with the board, already prepared for the first test, covered with the shield, and with the stylus inserted at the round alley (*S*) in the middle of the board, on a table in front of him The experimenter then gave the instructions described by Morgan and Hull

> You see these little alleys that the stylus can travel through? You take this stylus and trace through until it drops into a hole, see, this way

The experimenter traces to the first turn and then said,

> This first test is very easy, but, you see, here you can go two ways You must choose which way to go If the stylus

> does not drop into a hole, come back and try the other way When you find the hole, tell me and I will open up more of the board for you

Tests two, three and four were given in succession When the experimenter opened the board for the fourth test he said,

> Now you have practically the whole board to work on

The procedure of Morgan and Hull was followed throughout While working, if the subject said,

> You must have put these pegs in wrong

the experimenter usually smiled and said nothing, letting him interpret as he pleased. If this was not sufficient and the subject continued to ask questions in an effort to get a pointer the experimenter said,

> I am not supposed to talk while you are taking the test.

This is merely a statement of the attitude which has been preserved throughout the test, and serves to impress the subject with the worth of the test.

After the subject had worked for 10 minutes the experimenter would say

> Do not work longer than you wish If you can't find the hole, and do not care to try longer, you do not need to

On the basis of his performance on the maze the subject was rated at once on the following nine-point scale which was used by Morgan and Hull.

9 Careless—anxious to quit a task
8 Excuse hunter—always has an excuse to get out of work—feels badly, eyes hurt, time valuable, etc.
7 Fiddling plodder—keeps working because he has not enough initiative to try harder or quit, follows line of least resistance
6. Intermittent worker, goes by spurts, working hard and then has periods of fiddling.
5 Works hard but has little insight (really persistent, but not intelligent)
4 Persistent worker with some method or definite attempt to accomplish aim
3. Persistent worker with some insight but easily convinced Probably tries out two or three methods
2 Tenacious, obstinate type—more determined to succeed because of obstacles
1 Analytical type—intelligently persistent to the extent that he fully analyzes the problem Presents data well worked out to prove his conclusions

e *Whipple-Healy Tapping Test* requiring 30 seconds with same instructions as in part "*c*."

f *Whipple-Healy Tapping Test* requiring 30 seconds with same instructions as in part "*c*"

g *Arithmetic Schedule B* (*or A*) requiring 8 minutes Instructions were

> You have another eight minutes to find the answers to as many of these addition examples as possible

Results

The average ages of the ordinal groups comprising each of the two experimental samples used, the 6 *B*'s and the 6 *A*'s, are so alike that differences are negligible As shown in Table 2, in the 6 *B* sample the *Only* group, composed of 11 males and 7 females ranging in age from 127 to 147 months, showed the lowest average age of 137 5 months, the *Youngest,* 21 males and 21 females ranging from 118 to 158 months, averaged 137 8, the *Oldest,* 13 males and 16 females ranging from 125 to 150 months, averaged 139.0 months, and the *Middle* group, 6 males and 8 females ranging from 129 to 153 months, 135.0 Among the 6 *A*'s the *Oldest* group, composed of 6 males and 4 females ranging from 127 to 147 months in age, averaged 134 5 months, the *Only,* 6 males and 4 females ranging from 131 to 138 months, 135 0, the *Middle,* 7 males and 3 females from 136 to 146 months, 136 1; and the *Youngest,* 6 males and 4 females from 132 to 147 months, 137 0 Thus the greatest difference in average age among the 6 *B* groups did not exceed 3.2 months, and among the 6 *A*'s 2 5 months The four groups comprising each sample may, therefore, be considered equal in so far as average age is concerned and Intelligence Quotients do not have to be adjusted for age differences

An analysis of the range and distribution of the *IQ*'s of the two samples indicates that the two are well distributed from the viewpoint of normal distribution, with a tendency for the extremes of the scale to be somewhat larger than expectation Table 1 shows the observed as compared to the theoretical frequencies The average IQ for each of the two samples was somewhat high with the 6 *B*'s averaging 112 0 and the 6 *A*'s 114 0.

Table 2 shows the average *IQ*'s for the four ordinal positions

TABLE 1
DISTRIBUTION OF EXPERIMENTAL SAMPLES ACCORDING TO *IQ*'s

Scores	Mid-point	6 *B*'s Observed frequency	Theoretical frequency	6 *A*'s Observed frequency	Theoretical frequency
145-154	149.5	4	1.76	0	.36
135-144	139.5	5	5.99	2	1.96
125-134	129.5	14	14.18	8	6.07
115-124	119.5	18	22.85	9	10.88
105-114	109.5	28	25.12	12	11.23
95-104	99.5	22	18.88	5	6.64
85- 94	89.5	7	9.67	4	2.23
75- 84	79.5	5	3.44	0	.43
		$N = 103$	$Chi^2 = 6.34$	$N = 40$	$Chi^2 = 3.57$
		$Av = 112.0$		$Av = 114.0$	
		$SD = 16.2$		$SD = 13.4$	

The results obtained from the two experimental samples are remarkably similar. In both samples the group denoted as Youngest led with the highest average *IQ*, the Middle came second, the Oldest third, and the Only last. When these differences were subjected to statistical analysis we found that the chances in 100 that the true differences are greater than zero were greatest in respect to the Youngest as compared to the Only and Oldest, and smallest when comparing the Oldest and Middle. Table 2 gives these comparisons in detail. Consolidating the data in Table 2*a* we find that, for the 6 *B*'s, the First-born were represented by 24 males and 23 females ranging in age from 125 to 150 months with an average *IQ* of 108.45, and Subsequent-born by 27 males and 29 females ranging from 118 to 158 months with an average *IQ* of 113.82. Among the 6 *A*'s, the First-born included 12 males and 8 females with an age range of 127 to 147 months, average *IQ* 111.80, and the Subsequent-born 13 males and 7 females ranging from 126 to 147 months with an average *IQ* of 116.40. This consolidation to form two groups shows the range of *IQ*'s, the distribution of subjects, in per cent, and average *IQ*'s. The Subsequent-born are superior to the First-born in terms of average *IQ*, both in 6 *B* and 6 *A* samples.

An analysis of the average auditory-vocal forward digit spans of the two samples disclosed no such uniform agreement. Among the 6 *B*'s the Youngest gave the highest average Spans whereas among the 6 *A*'s they gave the lowest. The Oldest groups are consistently

TABLE 2

INTELLIGENCE QUOTIENTS (STANFORD REVISION OF THE BINET-SIMON)

	Order of birth	No of cases	Average age	Average score	$SD_{(dist.)}$	$\frac{D}{SD_{(diff.)}}$ Only	Youngest	Oldest	The chances that the true differences are greater than zero **chances in 100** Only	Youngest	Oldest
6 B	**Only**	**18**	**137 5**	**106 4**	**13 80**						
	Youngest	**42**	**137 8**	**114.5**	**16 43**	**1 96**			**98**		
	Oldest	**29**	**139 0**	**109 7**	**15 41**	**0 76**	**1.25**		**78**	**89**	
	Middle	**14**	**140 7**	**111.6**	**17 74**	**0 90**	**0 54**	**0 34**	**82**	**71**	**63**
6 A	**Only**	**10**	**135 0**	**109 6**	**12.79**						
	Youngest	**10**	**137 0**	**117 3**	**11.25**	**1 43**			**92**		
	Oldest	**10**	**134 5**	**114.0**	**14.06**	**0 73**	**0 58**		**77**	**72**	
	Middle	**10**	**136 1**	**115 5**	**15 35**	**0 94**	**0 30**	**0.23**	**83**	**62**	**59**

TABLE 2a

RANGE AND DISTRIBUTION OF INTELLIGENCE QUOTIENTS

Scores (step)	N	75-84	85-94	95-104	105-114	115-124	125-134	135-144	145-154	Average IQ
First-born	**47**	**6 38%**	**10 64%**	**23 40%**	**21 38%**	**19 15%**	**14 89%**	**4 26%**		**108 45**
First-born	*20*		*10 00%*	*15 00%*	*40 00%*	*10 00%*	*25 00%*			*111 80*
Subsequent-born	**56**	**3 57%**	**3 57%**	**21 43%**	**30 37%**	**16 07%**	**10 71%**	**7 14%**	**7 14%**	**113 82**
Subsequent-born	*20*		*10 00%*	*10.00%*	*20 00%*	*35 00%*	*15 00%*	*10 00%*		*116 40*

NOTE

(1) Only and Oldest groups combined as First-born

(2) Youngest and Middle groups combined as Subsequent-born.

Bold face figures—6 B's

Italic figures—6 A's

TABLE 3
AUDITORY-VOCAL DIGIT SPANS FORWARD

	Order of birth	No of cases	Average score	$SD_{(dist)}$	$\frac{D}{SD_{(diff)}}$ Only	$\frac{D}{SD_{(diff)}}$ Youngest	$\frac{D}{SD_{(diff)}}$ Oldest	The chances that the true differences are greater than zero **chances in 100** Only	Youngest	Oldest
6 B	**Only**	**18**	**6 4**	**0 90**						
	Youngest	**42**	**6 6**	**1 01**	**0 42**			**66**		
	Oldest	**29**	**6 3**	**0 91**	**0 59**	**1 18**		**72**	**88**	
	Middle	**14**	**6 4**	**0 73**	**0 03**	**0 48**	**0 58**	**51**	**68**	**72**
6 A	**Only**	**10**	**6 4**	**0 80**						
	Youngest	**10**	**6 2**	**0 87**	**0 53**			**70**		
	Oldest	**10**	**6 3**	**0 90**	**0.27**	**0 25**		**61**	**60**	
	Middle	**10**	**6 7**	**0 78**	**0 85**	**1 33**	**1 07**	**80**	**91**	**86**

TABLE 3*a*
RANGE AND DISTRIBUTION OF AUDITORY-VOCAL DIGIT SPANS

Score	*N*	5	6	7	8	Average span
First-born	**47**	**17 02%**	**44 68%**	**25 53%**	**12 77%**	**6 34**
First-born	*20*	*15 00%*	*45 00%*	*30 00%*	*10 00%*	*6 35*
Subsequent-born	**56**	**16 07%**	**32.14%**	**35 72%**	**16 07%**	**6 52**
Subsequent-born	*20*	*10 00%*	*50 00%*	*25 00%*	*15 00%*	*6 45*

NOTE
(1) Only and Oldest groups combined as First-born
(2) Youngest and Middle groups combined as Subsequent-born
Bold face figures—6 *B*'s
Italic figures—6 *A*'s

TABLE 4
AUDITORY-VOCAL DIGIT SPANS REVERSE

	Order of birth	No of cases	Average score	$SD_{(dist)}$	$\frac{D}{SD_{(diff)}}$ Only	$\frac{D}{SD_{(diff)}}$ Youngest	$\frac{D}{SD_{(diff)}}$ Oldest	The chances that the true differences are greater than zero **chances in 100** Only	Youngest	Oldest
	Only	**18**	**4 6**	**0 68**						
B	**Youngest**	**42**	**5 0**	**1 07**	**1 48**			**93**		
6	**Oldest**	**29**	**4 6**	**0 96**	**0 04**	**1 36**		**52**	**91**	
	Middle	**14**	**4.6**	**1 05**	**0 00**	**1 17**	**0 00**	**50**	**88**	**50**
	Only	**10**	**4.4**	**0 92**						
A	**Youngest**	**10**	**4 6**	**0 80**	**0 52**			**70**		
6	**Oldest**	**10**	**5 0**	**0 63**	**1 70**	**1 25**		**96**	**89**	
	Middle	**10**	**4.7**	**0 90**	**0 74**	**0 27**	**0 87**	**77**	**61**	**81**

TABLE 4a
RANGE AND DISTRIBUTION OF AUDITORY-VOCAL REVERSE DIGIT SPANS

	N	3	4	5	6	7	Average span
First-born	**47**	**8 51%**	**36 17%**	**42 55%**	**10 64%**	**2 13%**	**4 62**
First-born	*20*	*10 00%*	*30 00%*	*45 00%*	*10 00%*	*5 00%*	*4 70*
Subsequent-born	**56**	**10 71%**	**23 22%**	**46 43%**	**8 93%**	**10 71%**	**4 86**
Subsequent-born	*20*	*10 00%*	*30 00%*	*45 00%*	*15 00%*	*0 00%*	*4 65*

NOTE
(1) Only and Oldest groups combined as First-born
(2) Youngest and Middle groups combined as Subsequent-born

Bold face figures—6 *B*'s
Italic figures—6 *A*'s

low in both samples and the Middle and Only groups consistently higher. The differences among the averages are not, however, *reliable as indicated in* Table 3 Table 3*a* discloses an interesting distribution of scores Even though the differences between the averages are not reliable yet, among the 6 *B*'s only 38 per cent of First-born gave spans of 7 or over as compared to 52 per cent of Subsequent-born Among the 6 *A*'s this difference is not found

The results of the auditory-vocal reverse spans, as given in Table 4 are also inconsistent Again, among the 6 *B*'s the Youngest gave the highest average but fell to third position among the 6 *A*'s. In *both samples the average score of the Youngest is higher than the* Only, the chances of a true difference being observed varying between 70 and 93 Except for this the data show no agreement Again, however, we find that only 13 per cent of First-born gave spans of 6 or better as compared to 20 per cent of Subsequent-born Table 4*a* shows this in detail

The results of the performance on the two arithmetic schedules cannot be dealt with as simply as we have with the preceding. *Schedule "A" was given just before the subjects attempted the* Morgan and Hull Maze, and Schedule "*B*" was given subsequent to the maze The relative positions of the four groups, both 6 *B* and 6 *A*, is notably consistent for both schedules The order in average performance is as follows:

6 *B*		6 *A*	
Schedule *A*	Schedule *B*	Schedule *A*	Schedule *B*
Middle	Middle	Middle	Middle
Youngest	Youngest	Youngest	Youngest
Oldest	Only	Oldest	Oldest
Only	Oldest	Only	Only

Thus, the Middle group consistently led, the Youngest occupied second place, the Oldest, except for one variation, third place, and the Only, except for one variation, occupied last place The reliability of the differences of the performance of the Middle group is indicated by the fact that only when compared with the Youngest did the chances in 100 of a true difference fall below 93 Table 5 gives this detail.

Table 5a demonstrates the superiority of the performance of the Subsequent-born group as compared to that of the First-born Let us examine the scores on Arithmetic *A* and, for the moment, the

TABLE 5
ARITHMETIC

Order of birth		No of cases	Average score	$SD_{(dist)}$	$\frac{D}{SD_{(diff)}}$ Only	$\frac{D}{SD_{(diff)}}$ Youngest	$\frac{D}{SD_{(diff)}}$ Oldest	The chances that the true differences are greater than zero ***chances in 100*** Only	Youngest	Oldest
	Only	**18**	**5 3**	**2 87**						
	Only	*18*	*5 2*	*2 73*						
	Youngest	**42**	**6 3**	**2 90**	**1 21**			**89**		
9 B	*Youngest*	*42*	*6 0*	*2 99*	*0 99*			*84*		
	Oldest	**29**	**5 8**	**3 22**	**0 48**	**0 74**		**68**	**77**	
	Oldest	*29*	*4 9*	*3 21*	*0 31*	*1 39*		*62*	*92*	
	Middle	**14**	**7 3**	**3 28**	**1 77**	**1 00**	**1 44**	**96**	**84**	**93**
	Middle	*14*	*6 8*	*2 93*	*1 60*	*0 93*	*1 02*	*95*	*82*	*97*
	Only	**10**	**4 5**	**2 62**						
	Only	*10*	*4 0*	*2 45*						
	Youngest	**10**	**6 7**	**2 65**	**1 86**			**97**		
9 A	*Youngest*	*10*	*5 3*	*2 19*	*1.26*			*90*		
	Oldest	**10**	**5 5**	**2.66**	**0 85**	**1 01**		**80**	**84**	
	Oldest	*10*	*4 2*	*2 04*	*0 20*	*1 16*		*58*	*88*	
	Middle	**10**	**7 3**	**2 19**	**2.59**	**0 55**	**1 65**	**99 5**	**71**	**95**
	Middle	*10*	*6 5*	*1 63*	*2 69*	*1 40*	*2 77*	*99 6*	*92*	*99 7*

Bold face figures—Arithmetic Schedule "*A*"
Italic figures—Arithmetic Schedule "*B*"

TABLE 5a

RANGE AND DISTRIBUTION OF ARITHMETIC SCORES

	Score (No corr)	N	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Average score
Arith 1	**First-born**	**47**		**10.64%**	**10.64%**	**8.50%**	**8.51%**	**6.38%**	**17.02%**	**17.02%**	**2.13%**	**8.51%**	**2.13%**	**4.26%**	**2.13%**	**2.13%**	**5.60**
	First-born	*20*	*5.00%*		*10.00%*	*20.00%*	*15.00%*	*5.00%*	*20.00%*	*10.00%*	*5.00%*		*5.00%*	*5.00%*			*5.00*
	Subsequent-born	**56**	**1.79%**	**5.36%**	**1.79%**	**8.93%**	**5.36%**	**10.71%**	**19.63%**	**8.93%**	**10.71%**	**8.93%**	**5.36%**	**5.36%**	**7.14%**		**6.55**
	Subsequent-born	*20*				*5.00%*	*15.00%*	*10.00%*	*10.00%*	*25.00%*	*5.00%*	*15.00%*	*10.00%*			*5.00%*	*7.00%*
Arith 2	**First-born**	**47**	**2.13%**	**10.64%**	**17.02%**	**2.13%**	**14.89%**	**10.63%**	**10.63%**	**12.77%**	**8.51%**	**4.26%**		**2.13%**	**2.13%**	**2.13%**	**5.00**
	First-born	*20*		*5.00%*	*30.00%*	*10.00%*	*15.00%*	*15.00%*	*15.00%*		*5.00%*		*5.00%*				*4.10*
	Subsequent-born	**56**	**1.79%**	**5.36%**	**7.14%**	**3.57%**	**5.36%**	**19.64%**	**16.07%**	**10.71%**	**7.14%**	**14.29%**		**1.79%**	**3.57%**	**3.57%**	**6.16**
	Subsequent-born	*20*			*10.00%*	*5.00%*	*5.00%*	*20.00%*	*20.00%*	*15.00%*	*15.00%*	*10.00%*					*5.90*

NOTE

(1) Only and Oldest groups combined as First-born

(2) Youngest and Middle groups combined as Subsequent-born

Bold face figures—6 B's

Italic figures—6 A's

number of subjects who answered correctly two or less of the addition examples We find that, among the 6 *B*'s, 21 per cent of First-born gave such poor performances as compared to only 9 per cent of Subsequent-born. Among the 6 *A*'s we find a similar result with 15 per cent of First-born giving so poor a performance whereas no Subsequent-born made so low a score

Turning now to the high end of the scores we find the situation reversed,—19 per cent of First-born, among the 6 *B*'s, made scores of 9 or better as compared to 27 per cent of Subsequent-born Among the 6 *A*'s it was 10 per cent as compared to 30 per cent.

The performances on Arithmetic *B* could be shown to give essentially the same results as that found in Arithmetic *A* It is unnecessary to do this, however, since an examination of Table 5*a* will clearly demonstrate this point

The relative superiority of performance was not the only analysis made of the data secured from the Arithmetic Schedules The experimenter was also interested in determining the relative influence, if any, of the intervening maze situation upon the performance of the various groups as measured by comparing the scores achieved on Schedules *A* and *B* Table 6 gives these comparisons

TABLE 6

DIFFERENCES IN AVERAGE SCORES ON ARITHMETIC SCHEDULES *A* AND *B*

	Schedule *A* Average scores	Schedule *B* Average scores	% change in average	% change in variability
Only	**6.3**	**5 2**	**— 3 0**	**— 1.9**
Only	*4 5*	*4 0*	*—11 0*	*+ 5 1*
Youngest	**6 3**	**6 0**	**— 5.6**	**+ 9 3**
Youngest	*6 7*	*5 3*	*—20 8*	*+10 1*
Oldest	**5.8**	**4.9**	**—14 9**	**+17 9**
Oldest	*5 5*	*4 2*	*—23 6*	*+ 9 0*
Middle	**7 3**	**6.8**	**— 5 5**	**— 4 1**
Middle	*7 3*	*6 5*	*—11 0*	*—16 3*

Bold face figures— 6 *B* subjects
Italic figures—6 *A* subjects

It is evident from Table 6 that the results of the 6 *B*'s and 6 *A*'s are again consistent. All groups, both 6 *B*'s and 6 *A*'s, showed a decrease in accurate performance when Schedule *B* is compared to Schedule *A* The degree to which accuracy was reduced varied, however, from group to group The Only group showed the smallest

reduction, the Middle and Youngest were next and the Oldest showed the greatest reduction. This was true of both the 6 *B*'s and 6 *A*'s. The 6 *A*'s as a group showed a much larger reduction in number of examples correctly added than did the 6 *B*'s as a group, a finding which could have been anticipated since the 6 *B*'s were one-half year further advanced in the educational scale. The sole 6 *B* sub-group whose performance was as much curtailed as any of the 6 *A* groups was the Oldest This group showed a drop of 14.9 per cent, which decrease is 3 9 per cent greater than either the Middle or Only groups of the 6 *A* sample.

In the analysis of performance on the Whipple-Healy Test attention is again focused on these two factors, namely (*a*) on the relative differences in performance among the various ordinal groups as indicated by average scores, and (*b*) the relative change in performance on successive trials of each group as indicated by the per cent change in the average score.

In regard to the relative differences in performance, Tables 7 and 8 give the average scores for Trials 1, 2, 3 and 4, for both 6 *B*'s and 6 *A*'s If, on the basis of average score, the ordinal groups are again arranged in order of decreasing average, we find the following.

	Trial 1	Trial 2	Trial 3	Trial 4
		6 *B*'s		
Highest score	Oldest	Youngest	Youngest	Youngest
Next highest score	Youngest	Oldest	Only	Only
Next highest score	Only	Only	Oldest	Oldest
Lowest score	Middle	Middle	Middle	Middle
		6 *A*'s		
Highest score	Oldest	Oldest	Oldest	Youngest
Next highest score	Youngest	Youngest	Middle	Oldest
Next highest score	Only	Only	Only	Only
Lowest score	Middle	Middle	Youngest	Middle

From this arrangement the most outstanding point is that the Middle ordinal group consistently occupies the lowest score position. From Tables 7 and 8 we see that the scores of this group are not only consistent but also reliably poorer than any of the other groups. The chances in 100 that the average score of the Middle group will always be inferior to that of any of the other groups varies, except in two instances, between 82 and 99.6 The inferiority of the average scores of the Only group as compared to the Oldest and Youngest, although consistent are not as reliable, varying between

TABLE 7

WHIPPLE-HEALY TAPPING TEST

	Order of birth	No of cases	Average score	$SD_{(dist)}$	$\frac{D}{SD_{(diff)}}$ Only	Youngest	Oldest	The chances that the true differences are greater than zero *chances in 100** Only	Youngest	Oldest
	Only	**18**	**71.2**	**7.33**						
	Only	*18*	*72.3*	*8.34*						
	Youngest	**42**	**72.4**	**12.10**	**0.47**			**68**		
6 B	*Youngest*	*42*	*73.3*	*11.60*	*0.38*			*65*		
	Oldest	**29**	**73.0**	**8.74**	**0.76**	**0.24**		**78**	**59**	
	Oldest	*29*	*72.3*	*8.56*	*0.00*	*0.42*		*50*	*66*	
	Middle	**14**	**63.9**	**11.30**	**2.10**	**2.40**	**2.65**	**98**	**99**	**99.6**
	Middle	*14*	*68.9*	*8.80*	*1.11*	*1.49*	*1.20*	*87*	*93*	*88*
	Only	**10**	**70.1**	**4.67**						
	Only	*10*	*70.5*	*6.02*						
	Youngest	**10**	**69.8**	**7.01**	**0.11**			**54**		
6 A	*Youngest*	*10*	*71.9*	*6.20*	*0.51*			*70*		
	Oldest	**10**	**69.2**	**7.64**	**0.32**	**0.18**		**63**	**57**	
	Oldest	*10*	*72.0*	*8.79*	*0.45*	*0.03*		*67*	*51*	
	Middle	**10**	**63.4**	**9.24**	**2.06**	**1.74**	**1.53**	**98**	**96**	**94**
	Middle	*10*	*65.2*	*9.39*	*1.22*	*1.60*	*1.42*	*89*	*95*	*92*

Bold face figures—Tapping First Trial
Italic figures—Tapping Second Trial

TABLE 3

WHIPPLE-HEALY TAPPING TEST

Order of birth	No of cases	Average score	$SD_{(dist)}$	$\frac{D}{SD_{(diff)}}$ Only	Youngest	Oldest	The chances that the true differences are greater than zero **chances in 100** Only	Youngest	Oldest
Only	**18**	**72.7**	**9 81**						
Only	*18*	*71 6*	*9 88*						
Youngest	**42**	**76 4**	**13 90**	**1.18**			**88**		
B *Youngest*	*42*	*72.3*	*15 90*	*0.20*			*58*		
9 **Oldest**	**29**	**72 6**	**11 00**	**0 03**	**1 28**		**51**	**90**	
Oldest	*29*	*70 1*	*11 60*	*0.47*	*0 68*		*68*	*75*	
Middle	**14**	**65 6**	**23 30**	**1 07**	**1 64**	**1 07**	**86**	**95**	**86**
Middle	*14*	*62 3*	*31 10*	*1 08*	*1 16*	*0 91*	*80*	*88*	*82*
Only	**10**	**68 0**	**9 28**						
Only	*10*	*70 3*	*4 15*						
Youngest	**10**	**67 7**	**18 12**	**0 05**			**52**		
A *Youngest*	*10*	*74 3*	*5 66*	*1 80*			*96*		
9 **Oldest**	**10**	**71 8**	**5 51**	**1 11**	**0 68**		**87**	**75**	
Oldest	*10*	*71 5*	*5 16*	*0 57*	*1 16*		*72*	*88*	
Middle	**10**	**68 5**	**8 54**	**0 13**	**0 13**	**1 03**	**55**	**55**	**85**
Middle	*10*	*66 7*	*11 35*	*0 94*	*1 89*	*1 24*	*83*	*97*	*89*

Bold face figures—Tapping Third Trial
Italic figures—Tapping Fourth Trial

TABLE 8a

RANGE AND DISTRIBUTION OF WHIPPLE-HEALY TAPPING SCORES

	Scores (step) N	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	Average score
Trial 1 **First-born**	**47**					**2.13%**	**4.26%**	**27.66%**	**53.18%**	**8.51%**	**4.26%**		**72.31**
First-born	*20*							*45.00%*	*45.00%*	*10.00%*			*69.65*
Subsequent-born	**56**					**7.14%**	**14.29%**	**16.07%**	**44.64%**	**12.50%**	**3.57%**	**1.79%**	**70.28**
Subsequent-born	*20*						*25.00%*	*30.00%*	*40.00%*	*5.00%*			*66.60*
Trial 2 **First-born**	**47**					**2.13%**	**4.26%**	**31.91%**	**42.55%**	**19.15%**			**72.30**
First-born	*20*					*10.00%*	*25.00%*	*55.00%*	*10.00%*				*71.25*
Subsequent-born	**56**					**1.79%**	**10.71%**	**30.36%**	**35.71%**	**16.07%**	**3.57%**	**1.79%**	**72.20**
Eubsequent-born	*20*					*10.00%*	*40.00%*	*35.00%*	*15.00%*				*69.05*
Trial 3 **First-born**	**47**				**2.13%**		**8.51%**	**25.53%**	**34.04%**	**29.79%**			**72.64**
First-born	*20*					*5.00%*	*5.00%*	*30.00%*	*55.00%*	*5.00%*			*69.90*
Subsequent-born	**56**	**1.78%**			**1.79%**		**8.93%**	**17.86%**	**30.36%**	**28.57%**	**7.14%**	**3.57%**	**73.70**
Subsequent-born	*20*		*5.00*				*5.00%*	*35.00%*	*40.00%*	*15.00%*			*68.10*
Trial 4 **First-born**	**47**					**4.26%**	**10.64%**	**21.28%**	**40.42%**	**23.40%**			**70.67**
First-born	*20*							*35.00%*	*65.00%*				*70.90*
Subsequent-born	**56**	**3.57%**				**1.78%**	**16.07%**	**14.29%**	**33.93%**	**21.43%**	**8.93%**		**69.80**
Subsequent-born	*20*					*5.00%*	*10.00%*	*25.00%*	*45.00%*	*15.00%*			*70.50*

NOTE
(1) Only and Oldest groups combined as First-born
(2) Youngest and Middle groups combined as Subsequent-born

Bold face figures—6 *B*'s
Italic figures—6 *A*'s

TABLE 9

DIFFERENCES IN AVERAGE SCORES ON THE FOUR TRIALS OF THE WHIPPLE-HEALY TAPPING TEST

	Trial 1 Av score	Trial 2 Av score	% change in aver	% change in variab	Trial 3 Av score	% change in av	% change in variab	Trial 4 av score	% change in aver	% change in variab
Only	**71.2**	**72.3**	**+1.3**	**+12.1**	**72.7**	**+2.0**	**+32.3**	**71.5**	**+0.2**	**+34.4**
Only	*70.1*	*70.5*	*+0.7*	*+31.0*	*68.0*	*−3.0*	*+190.5*	*70.3*	*+0.2*	*−9.4*
Youngest	**72.4**	**73.3**	**+1.2**	**−5.3**	**76.4**	**+5.5**	**+8.9**	**72.3**	**0.0**	**+31.6**
Youngest	*69.8*	*71.9*	*+3.0*	*−14.1*	*67.7*	*−3.0*	*+166.2*	*74.3*	*+6.2*	*−24.3*
Oldest	**73.0**	**72.3**	**−0.9**	**−1.1**	**72.6**	**−0.5**	**+26.6**	**70.1**	**−4.0**	**+38.3**
Oldest	*69.2*	*72.0*	*+4.1*	*+10.8*	*71.8*	*+3.9*	*−30.5*	*71.5*	*+3.4*	*−34.6*
Middle	**63.9**	**68.9**	**+7.9**	**−27.8**	**65.6**	**+2.5**	**+100.0**	**62.3**	**−2.5**	**+182.3**
Middle	*63.4*	*66.2*	*+4.4*	*−2.6*	*68.5*	*+8.1*	*−14.4*	*66.7*	*+5.3*	*−16.8*

Bold face figures—6 *B* Subjects
Italic figures—6 *A* Subjects

50 and 97 chances in 100 that the true differences are greater than zero

Table 8a consolidates the data for purpose of comparison into First-born and Subsequent-born It is observed that the average scores are slightly higher in favor of the First-born, but essentially these differences are of little consequence Of greater interest is the distribution of scores, and here we find the Subsquent-born group dominating the extremes of the distribution, both the low and the high The extremely low scores do not appear until Tapping Trial 3 or, in other words, they appear after the performance on the Morgan and Hull maze The high scores, on the other hand, are present throughout

Proceeding to the second point regarding alterations in performance with succeeding trials, Table 9 makes this analysis in terms of per cent change in average score and per cent change in variability Here we find that the Middle group displayed the highest increases in average score on succeeding trials and the Only group displayed the least change. These observations are readily understandable when coupled with the fact that the Middle group's low level of initial performance in tapping permitted a much wider range in which to improve, whereas the Only group's performance began on a high level and left relatively less room for improvement

Comparisons in terms of variability (Table 9) of the average performance on the third trial, the trial following the maze situation, the Only group showed the greatest increase, the Youngest next, and the Oldest least On the succeeding trial, the fourth, the Middle group rose to first position in terms of increase in variability.

Table 10 presents the statistical treatment of the ratings of Persistence Following Morgan and Hull's nine-point rating scale, Persistence increases as the number decreases, i e , No 9 represents the low extreme of the Persistence scale and No 1 represents the high extreme The ratings, of course, represent the judgment of the experimenter based upon the observable performance of the subject in the maze situation.

If we arrange the various ordinal groups on the basis of average ratings, ranging from the lowest (i e , most persistent) to the highest (i e , least persistent) we get the following arrangement

TABLE 10
PERSISTENCE

	Order of birth	No of cases	Average score	$SD_{(dist)}$	$\frac{D}{SD_{(diff)}}$ Only	Youngest	Oldest	The chances that the true differences are greater than zero *chances in 100*** Only	Youngest	Oldest
6 B's	**Only**	**18**	**6.0**	**2.11**						
	Youngest	**42**	**4.6**	**1.78**	**2.39**			**99**		
	Oldest	**29**	**6.7**	**1.93**	**1.18**	**4.60**		**88**	**99.6**	
	Middle	**14**	**4.7**	**1.48**	**2.03**	**0.14**	**3.76**	**98**	**56**	**99**
6 A's	**Only**	**10**	**5.8**	**1.60**						
	Youngest	**10**	**4.8**	**1.25**	**1.54**			**94**		
	Oldest	**10**	**6.1**	**1.38**	**0.45**	**2.20**		**67**	**99**	
	Middle	**10**	**5.1**	**1.51**	**1.00**	**0.48**	**1.54**	**84**	**68**	**94**

TABLE 10a
RANGE AND DISTRIBUTION OF MORGAN AND HULL PERSISTENCE RATINGS

Rating	N	9	8	7	6	5	4	3	2	1	Average rating
First-born	**47**	**21.28%**	**12.77%**	**19.15%**	**10.64%**	**25.52%**	**0.00%**	**6.38%**	**2.13%**	**2.13%**	**6.45**
First-born	*20*	*5.00%*	*10.00%*	*25.00%*	*15.00%*	*30.00%*	*10.00%*	*5.00%*			*5.95*
Subsequent-born	**56**	**1.79%**	**7.14%**	**8.93%**	**3.57%**	**28.57%**	**25.00%**	**17.86%**	**5.36%**	**1.78%**	**4.66**
Subsequent-born	*20*		*5.00%*	*10.00%*	*15.00%*	*35.00%*	*15.00%*	*20.00%*			*4.95*

NOTE
(1) Only and Oldest groups combined as First-born
(2) Youngest and Middle groups combined as Subsequent-born

Bold face figures—6 *B*'s
Italic figures—6 *A*'s

	6 *B*'s	6 *A*'s
Most persistent	Youngest	Youngest
Next persistent	Middle	Middle
Next persistent	Only	Only
Least persistent	Oldest	Oldest

The arrangement of the ordinal groups of the 6 *B* sample coincides with that of the 6 *A* sample. The Youngest group holds the position of most persistent, the Middle are second, the Only are third, and the Oldest are last. From Table 10 we see that the average ratings of the Youngest group are reliably superior to the ratings of the Only and Oldest groups, the chances of the differences being true all being well over 90. However the differences between the Youngest and Middle groups are not anywhere near as reliable, being 56 chances in the 6 *B* sample and 68 in the 6 *A* sample. The superior ratings of the Middle group as compared to the Oldest and Only groups are, on the other hand, reliable, ranging from 84 to 99 chances in 100. The differences in ratings between the Oldest and Only groups are fairly reliable but not conclusive. The chances of a true difference are 88 in the 6 *B* sample, and 67 in the 6 *A* sample. The latter result is, of course, not reliable.

TABLE 11

COMBINED PARENTAL PREFERENCE

Preference	Father	Mother	None	No. of cases
Only	2	13	13	28
Youngest	4	8	40	52
Oldest	5	14	20	39
Middle	0	2	22	24

TABLE 11*a*

COMBINED PARENTAL PREFERENCE IN PER CENT

Preference	Father	Mother	None	% of cases
Only	7.2%	46.4%	46.4%	100.0
Youngest	7.7%	15.4%	76.9%	100.0
Oldest	12.8%	35.9%	51.3%	100.0
Middle	0.0%	8.3%	91.7%	100.0

TABLE 11*b*

COMBINED PARENTAL PREFERENCE IN PER CENT

Preference	Father	Mother	None	% of cases
First-born	10.44%	40.30%	49.25%	100.0
Subsequent-born	5.26%	13.16%	81.58%	100.0

Table 10*a* combines the Only and Oldest group to form the First-born, and the Youngest and Middle group to form the Subsequent-born It is clearly evident, not only from a comparison of the averages, but also from an examination of the distribution of the ratings that Subsequent-born received more high and fewer low ratings of Persistence than did First-born.

Data of a different nature are presented by Table 11 All the subjects were asked, but not urged, to express a parental preference if any The information was solicited in as normal a manner as possible and the child's answer was never questioned Since school level differences have no significance here, the data of the 6 *B* group have been combined with that of the 6 *A* group to form a composite.

Table 11 discloses wide differences in the preferences among the several ordinal groups Whereas 46.4 per cent of the Only group state that they have no parental preference, 91 7 per cent, over twice as many, of the Middle group said they had no preference. It is noteworthy that the Oldest group gave similar results to the Only group, while the Youngest group more closely resembled the Middle group See Table 11*b* for this consolidation

Maternal preference was expressed by 8 3 per cent of the Middle group and 15 4 per cent of the Youngest groups as compared to 35 9 per cent of the Oldest and 46 4 per cent of the Only groups Paternal preference was expressed by 12 8 per cent of the Oldest, 7.2 per cent of the Only, 7 7 per cent of the Youngest, and not at all by the Middle group

Conclusions

The data presented herein may, in general, be divided into two categories, first, that data which confirms previous experimentation and, second, that data which offers new evidence regarding psychological differences among the several ordinal positions.

In both instances differences can be attributed only to variations in environmental influences and not to differences in genetic or protoplasmic constitution. Freeman (20) has ably demonstrated in a recent article concerning observed cases of identical twins who were separated and reared in different environments that psychological differences of relatively large magnitude were found between individuals who were genetically alike Differences in *IQ*'s as well as in personality were observed

It is generally recognized that within any particular family the uniformity of environmental influences for the various children is more apparent than real. The very fact that a child is born second in the family instead of first is sufficient to create an entirely different environment, psychologically. Just how different this new environment is is problematical, although speculation is by no means absent. The differential influences of these varying environments are subtle and elusive and may never be fully disclosed. Studies, such as this, attempt to learn something about these variations in environment, not by studying the environments themselves, but by studying the differential influences as they are reflected in psychological traits which are amenable to measurement.

The findings of this study are strengthened by the use of two experimental samples instead of one. Since the two samples were selected by different methods of sampling, i.e., the 6 *B* group was selected on the basis of using all 6 *B* subjects available, and the 6 *A* group was selected by the taking of small random but equal samples from all the 6 *A* subjects available, the results of the one act as a check upon the other. The representativeness of each of the two samples has already been demonstrated.

The first striking thing about all the data presented herein is that the performance of the Only and Oldest groups more closely than not resemble each other. This is true also of the Youngest and Middle groups. This resemblance is apparent not only from an examination of the average ratings, but is also enhanced by the lack of reliable differences. For this reason the data has been presented not only in the historically accepted groupings of Only, Oldest, Youngest and Middle, but has also been grouped as First-born and Subsequent-born, since this grouping seems to be more in accordance with the facts.

In respect to Intelligence Quotients the findings of this study agree with those experiments of most recent date, namely those of Commins (15) in 1927, Thurstone and Jenkins (65) 1929, and Locke and Goldstein (38) 1937. The evidence points to a consistent tendency for the later born to be superior in intelligence. The average *IQ*'s of first-born children, regardless of whether they are Only or Oldest, more closely resemble each other than resemble the average *IQ*'s of subsequent-born children. The same may also be said of the later-born. No reliable differences were found for

digit spans, both forward and reverse, even though they play an important rôle in the determination of the *IQ* in Terman's revision of the Binet-Simon scale

The average performance of the several ordinal groups on the Arithmetic Schedules indicates again a superiority of later-born children over first-born This superiority is apparent not only when the results of each schedule are dealt with separately, but also when the results of one schedule are compared with that of the other schedule Regardless of whether we attribute the decrease in performance from Schedule *A* to Schedule *B* as being due to fatigue, emotional disturbance, or a combination of both, it is significant that first-born should show a much larger reduction in average performance over that of later-born Stratton's (60) study, which indicated that first-born are more prone to anger than others, suggests that first-born may be more prone to emotional disturbance because of a thwarting situation and thus affect performance to a greater degree than for later born This alteration of performance was not, however, observed on the sensori-motor level The results of the Whipple-Healy *Tapping Test* are too confused to be reliable except to indicate that the performance of the Middle group was consistently inferior to all of the other groups

The results of the measure of Persistence again indicate that *first-born are, on the average, inferior in regard to this trait as* compared with subsequent-born children The division into four ordinal groups seems to be artificial because the differences between the Only and Oldest groups, on the one hand, and the Youngest and Middle groups, on the other, are not reliable The differences between First-born and Subsequent-born are, however, clearly evident and would indicate that this is the more natural division

The differences in parental preference expressed by the several ordinal groups are very suggestive of the existence of differential parental behavior to children of various ordinal positions The solicitude which parents, and in particular mothers, shower upon their first-born is reflected by the preponderance of maternal preference expressed by first-born as compared to later-born That this over-solicitude is withdrawn from subsequent children is indicated by the decrease in expressed maternal preference from 46+ per cent of Only children to 8 3 per cent of Middle children.

Since it is axiomatic that genetic makeup of an individual is not in any way affected by the order in which fecundation has taken place,

that it can be expressed in terms of probability without considering ordinal relationships, it follows that, if environmental influences are equal, the expectation for any particular ordinal group will be the same as for any other group, and all ordinal positions taken as a single group If, therefore, reliable differences are found to exist between ordinal groups, and all scientific conditions of sampling are satisfied, the differences must be attributed to differences in environmental influences and not genetic differences The findings of this study would then indicate that the variations in the psychological factors studied are the products of differential environmental influences, which influences are different for first-born and those born subsequently The development of initiative and self-sufficiency of first-born is impeded by the protectiveness and over-indulgence of their parents With subsequent-born children this interference with development is not as marked, due perhaps to the wearing off of the factor of novelty surrounding children and also, perhaps, to the accumulation of experience derived from rearing the first-born The differential environmental influences are, therefore, in the case of later-born, more favorable for the attainment of levels more in accordance with the potentialities of the child than they are for first-born

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FACTORS OF CHANCE IN THE TRUE-FALSE EXAMINATION*

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There are devices which have satisfied educational need over a period of time which have been tested very little to determine their limitations before their adoption. They meet certain philosophical standards, they are needed by a large number of educators, and are adopted. The true-false test is one of these. The essay-type test failed in its objectiveness, and those interested in measurement cast anxiously about for something to take its place. The true-false test seemed to be one of the solutions to the problem.

At the present time many of our present and former practices are being subjected to scientific experimentation. There is much said and done concerning the value of reflective thinking. It is fostered in our elementary schools, high schools, and colleges. This attitude of reflective thinking is producing changes at all age levels of life and growth. Changes which are transforming practices are occurring with startling rapidity in the field of education. These changes usually are due to a dissatisfaction with an existing order of things, are an outgrowth of a passion for improvement, or are produced by discoveries of new truth.

> Wherever one turns . . . he finds technically trained scholars patiently and methodically applying the instruments and technique of science to numerous unsolved problems in the field of education (1).

The present study and discussion of the true-false test does not attempt to discredit the fact that the true-false test has been and will continue to be an important contribution to educational procedure. However, it shows definitely that the factor of chance may and does operate rather definitely in favor of high scores for some of the individuals taking this type of test, and just as definitely in

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opposition to high scores for other individuals taking the test, even though the test is graded by the right-minus-wrong-equals-zero hypothesis

The greater the number of statements guessed at on a true-false test the greater influence the factor of chance has in determining the size of the score

The advocates of the true-false test have disposed of the factor of chance by assuming that it is of little importance if the formula, rights-minus-wrongs-equal-zero, is applied Their arguments for its negligible influence were based upon the fact that if a coin is flipped 1,000 times the resulting score will be approximately 500 heads and 500 tails. McCall flipped a coin 50,000 times and kept a record of the total number of heads and tails His results were 25,000 heads and 24,999 tails. He maintains that except for a miscount somewhere the two would have probably come out even (2)

Due to the fact that for any large number of flips, such as 1,000 or 50,000, the heads and tails are approximately equal, it is assumed that the formula, rights-minus-wrongs-equal-zero, will give highly accurate results for any number of true-false statements a test may contain even though the person taking it is "absolutely innocent of any knowledge" concerning it and guesses at all the statements. It is argued that a person guessing at as few as 20 true-false statements will mark 10 of them right and 10 of them wrong Thus, he will have a score of zero which will be correct because he had no knowledge of the test and guessed at all the statements This is a beautiful philosophy of the test, but the argument is faulty Why base an argument concerning 20 units of chance upon the result of 50,000 units of chance and then say that chance operates equally in both cases?

The formula, rights-minus-wrongs-equal-zero, will give zero results consistently only when the number of guessed statements far exceeds 10, 25, 40, 70, or 100 statements on each test Instead of flipping a coin 50,000 times and determining the number of heads and tails included in the total number of flips, why not flip the coin the same number of times as there are true-false statements and determine from this quantity of flips the number of heads and tails? Such a method would give comparable results. The process could then be repeated many times with the same amount of effort

that it would take to determine the heads and tails for such a large number of flips For example to support an argument that a 20 statement test will be scored 10 right and 10 wrong in case the pupil is guessing, why not flip a coin 20 times and then determine the number of heads and tails This process could be repeated 2,500 times by flipping a coin 50,000 times There is nothing complicated with such an experiment Anyone with a penny for laboratory equipment and enough patience may verify the experiment

Since we are not constructing tests of 50,000 or even 1,000 true-false statements, we mistake when we reason that because the heads and tails are approximately equal for such large numbers that the same will be true for smaller numbers such as 20 or 100

Studies of Chance Will Vary

The writer of this article realizes that since the factor of chance varies as it does, no two experiments will produce exactly the same results, even though the same procedure is followed in obtaining the results However, there seem to be certain patterns of chance that agree rather definitely with each other. Therefore the pattern revealed by this study will closely resemble the pattern found in any other study

Section I

This study has been divided into two sections The *first* section contains those distributions which give the degree or extent in which the heads exceed the tails on any one count, or the extent in which the tails exceed the heads on any one count The second section gives hypothetical distributions of scores by assuming that a certain number of statements are known to the pupils taking the test and that another specified number on the same test are guessed statements

1 *Plan of Part I.*

The following procedure was followed in obtaining the results of the first part of this study An interest in the factors of chance was awakened in a class in social economics after a true-false test of 100 statements had been administered to a group of high school pupils The question concerning the extent to which chance factors influence true-false test scores was raised and discussed by the pupils Their interest became so awakened in the

problem that they became enthusiastic about a cooperative experiment for the purpose of helping determine the extent of these chance factors.

After the pupils had been made aware of the need of accuracy in the results which each of them obtained, each was provided with a coin, permitted to flip his coin, and record the respective number of times his flips resulted in a head or a tail The head or the tail resulting with each flip was recorded in the exact order in which each flip occurred What fun it was and how important each pupil felt in his effort to expand educational knowledge!

After the flipping was completed, the papers were scored by subtracting the lesser number from the greater and designating this score as a head or tail depending upon which one exceeds the other The process outlined above was followed until there were 50 sheets having 100 flips recorded on each of them, 50 sheets having 70 flips recorded on each of them, 50 sheets having 40 flips recorded on each of them, 50 sheets having 25 flips recorded on each of them, and 50 sheets having 10 flips recorded on each of them

The results of each set of papers were arranged into frequency distributions. Each of these frequency distributions is designated by the number of flips used in determining it and tabulated in Table 1 This table shows a distribution of the scores according to the degree in which the number of heads exceeded the number of tails, or the degree in which the number of tails exceeded the number of heads on each paper The author has named the method described in the preceding paragraphs the "*f*" method This was done for the purpose of convenient reference.

Column 1 shows the extent in which the heads exceeded the tails or the extent in which the tails exceeded the heads The figures in Column 2 show the number of papers on which the heads exceeded the tails and those in Column 3 the number of papers on which the tails exceeded the heads It is well to remember that all 50 papers of 100 flips in length are recorded in Columns 2 and 3 The figures in Column 2 should be read as follows: There were four papers on which the heads exceeded the tails by 2, there were five papers on which the heads exceeded the tails by 8, there were four papers on which the heads exceeded the tails by 16, there was one paper on which the excess of heads over tails amounted to 18, and there

TABLE 1

Distribution of Scores According to the Degree in which the Number of Heads Exceeded the Tails, or According to the Degree in which the Tails Exceeded the Heads on Each Paper when Successive Flips of the Coin Were Recorded and the Lesser Number Subtracted from the Greater Number "f" Method

Degree of excess of heads or tails	Number of flips recorded on each paper: 100 Frequency Heads	Tails	70 Frequency Heads	Tails	40 Frequency Heads	Tails	25 Frequency Heads	Tails	10 Frequency Heads	Tails
1	2	3	4	5	6	7	8	9	10	11
1							6	7		
2	4	6	5	3	8	5			9	14
3							5	5		
4		4	5	5	3	10			3	5
5							4	5		
6		4	5	3	3	2			1	3
7							1	4		
8	5	6	1	3	1	2			4	1
9							4	2		
10		3	1	1	3	4				
11							1	1		
12			1	1						
13							1			
14	4	4		2						
16	2			3	1					
18	1	1	3		1					
22	2									
24			1							
0	4		7		7				10	
Totals	50		50		50		50		50	
Flips	5,000		3,000		2,000		1,250		500	
Excess	0	6	2	0	0	0	0	17	0	6

Total Units of Chance 12,250
Total Excess of Tails over Heads 27

were two papers on which the excess of heads over tails equaled 22 Column 3 may be read in the same way for the excess of tails over heads

There were four of the fifty papers on which the heads and tails were exactly even The total number of flips for the 50 papers at 100 flips for each paper amounts to 5,000 flips The total excess of tails over heads for the 50 papers, tabulated in Columns 2 and 3, is 6 The remaining pairs of columns should be interpreted in the same manner as Columns 2 and 3

The total coin flips for Table 1 amount to 12,250 The excess of tails over heads amounts to only 27 for the entire 12,250 flips

TABLE 2

DISTRIBUTION OF SCORES ACCORDING TO THE DEGREE IN WHICH THE NUMBER OF RIGHTS EXCEEDED THE WRONGS, OR ACCORDING TO THE DEGREE IN WHICH THE WRONGS EXCEEDED THE RIGHTS ON EACH PAPER WHEN SUCCESSIVE COIN FLIPS WERE RECORDED AND GRADED BY A KEY CONSTRUCTED FOR A REGULAR CLASSROOM TEST "*f-k*" METHOD

Degree of excess of rights or wrongs	Number of flips recorded on each paper: 100 Frequency R	W	70 Frequency R	W	40 Frequency R	W	25 Frequency R	W	10 Frequency R	W
1	2	3	4	5	6	7	8	9	10	11
1							7	9		
2			6	3	7	6			8	16
3	6	3	7	4	6	7			4	5
5							1	4		
6			4	2	3	3			4	
7							3			
8	4	4	4	6	1	2				
9							2			
10					2					
11								2		
12	7	2	2	3		3				
13							1			
14				2	3	1				
16	5	5	3							
20	1	1								
24	1	3								
28	1									
32	1									
36		1								
0	5		4		6					13
Total	50		50		50		50			50
Flips	5,000		3,500		2,000		1,250			500
Excess	48		22		2		22		4	

Total units of chance 12,250
Total excess of rights over wrongs 98

This slight difference of heads and tails checks rather definitely with the experiment of McCall and with the experiments of other writers in this field

2. *Plan of Part II.*

In order to get a better picture of the true conditions produced by chance factors, keys were obtained that had been constructed by teachers for scoring the responses of pupils to true-false examinations These keys had been used for tests which had been administered some time prior to the flipping of the coins There were five keys, one

of which corresponded with each of the different lengths of the sets of papers constructed as a result of the coin flipping There was a key for a test of 100 true-false statements, one for a test of 70 true-false statements, one for a test of 40 true-false statements, one for a test of 25 true-false statements, and one for a test of 10 true-false statements.

In scoring, a head was marked as a response of true would have been marked on a regular true-false test, and a tail was marked as a response of false would have been marked on a true-false test The formula, rights-minus-wrongs-equal each individual's score, was applied and the result for each paper was tabulated. The results are shown in Table 2, which is constructed in the same manner as Table 1

This table shows the distribution of scores according to the extent in which the different flips agree with the key and are marked as right, or the extent in which the different flips lack agreement with the key and were marked as wrong The second plan is referred to in the study as the "*f-k*" method

The chance factors shown in Column 2 give to one pupil in this distribution an advantage equal to 32 true-false statements Chance places another pupil's marks at a disadvantage of 36 statements This gives the luckiest pupil an advantage of 68 statements over the unluckiest pupil. Since these figures were arrived at from a mere game of chance, it is reasonable to conclude that, on a test containing 100 true-false statements which are unknown to two different pupils, one may make a score of 68 statements greater than the other, although a difference as great as this occurs rather infrequently. Is such an advantage, when it does occur solely as a matter of chance or is due solely to guessing, worthy of consideration in test construction and scoring?

Table 2 shows the advantages for all different lengths of tests included in this study From a study of the differences in the extreme ranges it will be seen that the ratio of advantage increases inversely although not in exact proportion to the decrease in the number of guessed statements Certainly these are worthwhile facts to remember in scoring and constructing true-false tests

3. *Plan of Part III*

The third part of the study was planned as a check on the other two parts of the study. Table 3 shows a distribution of scores the

TABLE 3

Distribution of Scores According to the Degree in which the Number of Heads Exceeded the Tails, or According to the Degree in which the Tails Exceeded the Heads on Each Throw when the Number of Coins Specified Below Were Placed in a Dice Cup, Well Shaken, and the Resulting Number of Heads and Tails Counted and Recorded "c" Method

Degree of excess of heads or or tails	Number of coins included in each shake 100 Frequency Heads	Tails	70 Frequency Heads	Tails	40 Frequency Heads	Tails	25 Frequency Heads	Tails	10 Frequency Heads	Tails
1	2	3	4	5	6	7	8	9	10	11
1							8	12		
2	3	5	4	5	3	10			8	9
3							5	7		
4	2	4	7	5	4	3			6	9
5							3	2		
6	6	3	4		3	9			3	2
7							5	4		
8		2	6	2	4	2				
9							2	2		
10	5	4	5			3				
12				1	1	1				
14	1	1		1	1					
16	2		2	2	1					
18		2								
20			1							
22	1									
26		1	1							
0	6		4		5				13	
Total	50		50		50		50		50	
Units	5,000		3,500		2,000		1,250		500	
Excess	36	0	132	0	0	30	0	0	2	0

Total units of chance 12,250
Total excess of heads over tails 140

frequency of which was determined by putting the specified number of coins in a "dice cup," shaking them well, pouring them out, and counting the number of heads and tails. There were 100 pennies in the cup for the first 50 throws After each throw the coins were counted and the excess of either heads or tails were recorded These were then tabulated in Columns 2 and 3 according to the frequency of extent for the excess The same process was followed for 50 throws each of the following number of coins 70, 40, 25, and 10 Table 3 shows that the results obtained by this method agree very definitely with the results obtained by the other two methods

The frequency of individual units of chance occur with little

uniformity. However, the frequency of any large number of these units occur with a high degree of uniformity. This study points out the fact that *any large number of these units occur in accordance* with a rather definite pattern. The findings for each of the different spans of chance recorded in Tables 1, 2, and 3 indicate that the longer the true false test the less advantage will be given by chance factors when the formula, rights-minus-wrongs, is applied in scoring it.

Section II

1. *Hypothetical Grade Distributions*

The different distributions preceding this section have shown that individual scores vary when a group of statements are scored by pupils who have no knowledge concerning their true or false condition. The preceding tables have not given a very definite conception of the type of distribution which would result in case a knowledge was had concerning the true or false condition of a certain number of statements, in case no knowledge was had concerning the true or false condition of a certain number of statements on the same test. This condition is more comparable to the actual testing conditions as they exist in actual practice. In order to make the data more comparable to actual situations, the writer has built up a number of hypothetical distributions of scores based upon a definite number of chance units in each distribution. The patterns of chance found in the first part of this study and displayed in Tables 1, 2, and 3 were utilized in constructing these hypothetical distributions.

It was necessary to assume that the different classes of which the hypothetical distributions are characteristic were composed of pupils each of whom possessed an equal amount of knowledge concerning the truthfulness or falseness of an equal number of statements, and that each pupil guessed at an equal number of the statements. This does away with the heads and tails or the positive and negative effect of the distribution and makes the entire distribution positive.

Table 4 shows three such distributions. Each distribution has been built up by the previously-explained data obtained by the "*f*", "*f-k*", and "*c*" methods, respectively. These three distributions are based upon the assumption that a class of 50 pupils know concerning the truthfulness or falseness of exactly 50 statements on a test containing 150 such statements, and guess at the status of the re-

TABLE 4

THREE CHANCE DISTRIBUTIONS OF GRADES BASED UPON THE ASSUMPTION THAT A CLASS OF 50 PUPILS KNOW EXACTLY 50 TRUE-FALSE STATEMENTS ON A TEST, AND GUESS AT ANOTHER 100 STATEMENTS ON THE SAME TEST WHEN THE DISTRIBUTIONS ARE CONSTRUCTED BY MEANS OF THE "*f*", "*f-k*", AND "*c*" METHODS, RESPECTIVELY

Score		Method "*f*"	Method "*f-k*"	Method "*c*"
1		2	3	4
82			1	
78			1	
74			1	
72		2		3
70			1	
68		1		
66		2	5	2
64		4		1
62			7	
60				5
58		5	4	
56				6
54			6	2
52		4		3
50		4	5	6
48		6		5
46		4	3	4
44		4		
42		6	4	3
40		3		2
38			2	4
36		4		1
34			5	
32		1		2
30			1	
28				
26			3	
24			1	1
Total		50	50	50
Range	Ext	32-72	24-82	24-72
	Dif	40	58	

maining 100 statements. Column 1 of this table designates a group of scores descending in value from 82 to 24. Column 2 shows the frequency of the scores determined by the "*f*" method, Column 3 the frequency of the scores determined by the "*f-k*" method, and Column 4 the frequency of the scores determined by the "*c*" method As an example of the reading of this table, it would be said that there were two pupils who had definite knowledge of only 50 statements but who through pure chance make a score of 72 according

to the "*f*" method of determination The other frequencies of this column as well as those of columns 3 and 4 would be read in the same manner.

The range of the scores in Column 2 are from 32 to 72, with a difference between these two extremes of 40

The hypothetical distribution of these scores determined by either method of pure chance very closely resembles an ordinary class distribution of scores obtained by administering a true-false test to a class of pupils under normal conditions It is difficult, therefore, to determine the amount of a score on a true-false test that is due to learning and the amount that is due to pure chance As an illustration, it could not be determined under ordinary true-false test conditions, in case a like distribution were obtained, whether the two scores of 72 in Column 2 were the result of chance or whether they

TABLE 5

THREE CHANCE DISTRIBUTIONS OF GRADES BASED UPON THE ASSUMPTION THAT A CLASS OF 50 PUPILS KNOW EXACTLY 30 TRUE-FALSE STATEMENTS ON A TEST, AND GUESS AT THE OTHER 70 STATEMENTS WHEN THE DISTRIBUTIONS ARE CONSTRUCTED BY MEANS OF THE "*f*", "*fk*", AND "*c*" METHODS, RESPECTIVELY

Score		Method "*f*"	"*f-k*"	"*c*"
1		2	3	4
64		1		
56				1
50				1
48		3		
46			3	2
42		1	2	
40		1		5
38		1	4	6
36		5	4	4
34		5	7	7
32		5	6	4
30		7	4	4
28		3	3	5
26		5	4	5
24		3	2	
22		3	6	2
20		1		
18		1	3	1
16		2	2	1
14		3		2
Total		50	50	50
Range	Ext	14-56	16-46	14-64
	Dif	42	30	50

TABLE 6

THREE CHANCE DISTRIBUTIONS OF GRADES BASED UPON THE ASSUMPTION THAT EACH PUPIL IN A CLASS OF 50 PUPILS KNOWS EXACTLY 60 TRUE-FALSE STATEMENTS ON A TEST OF 100 STATEMENTS, AND GUESSES AT THE REMAINING 40 STATEMENTS WHEN THE DISTRIBUTIONS ARE CONSTRUCTED BY MEANS OF THE "f", "f-k", AND "c" METHODS, RESPECTIVELY

Score		Method "f"	"f-k"	"c"
1		2	3	4
78		1		
76		1		1
74			3	1
72				1
70		3	2	
68		1	1	4
66		3	3	3
64		3	6	4
62		8	7	3
60		7	6	5
58		5	6	10
56		10	7	3
54		2	3	9
52		2	2	2
50		4		3
48			3	1
46			1	
Total		50	50	50
	Ext.	50-78	46-74	48-76
Range	Dif	28	28	28

were the result of learning, or what per cent of them were due to both. Since the factor of chance does not operate uniformly, it should also be noted that there is no way of adequately correcting for chance.

It should be pointed out in defense of the true-false examination that ordinarily a class would know a higher percentage than would be expressed by the ratio of 50 statements known of a possible 150 statements. Although the distribution might resemble that of Table 4, the chance factors in the distribution would probably correspond more closely to the distributions shown in Tables 7 and 8.

Table 5 shows three chance distributions based upon the assumption that a class of 50 pupils each know exactly 30 true-false statements, and that each guesses at the other 70 statements on a test of 100 statements. This table is constructed according to the same plan as that of Table 4 and should be read in the same manner.

TABLE 7

THREE CHANCE DISTRIBUTIONS OF GRADES BASED UPON THE ASSUMPTION THAT EACH PUPIL IN A CLASS OF 50 PUPILS KNOWS EXACTLY 75 TRUE-FALSE STATEMENTS ON A TEST CONTAINING 100 STATEMENTS, AND EACH PUPIL GUESSES AT THE REMAINING 25 STATEMENTS WHEN THE DISTRIBUTIONS ARE CONSTRUCTED BY MEANS OF THE "f", "f-k", AND "c" METHODS, RESPECTIVELY

Score		Method "f"	"f-k"	"c"
1		2	3	4
88		1	1	
86		1		
84		4	2	2
82		1	3	5
80		4	1	3
78		5	12	5
76		6	7	6
74		7	9	12
72		5	9	7
70		9	4	2
68		4		4
66		2		2
64		1	2	
Total		50	50	50
Range	Ext	64-88	64-88	66-84
	Dif	18	24	24

TABLE 8

THREE CHANCE DISTRIBUTIONS OF GRADES BASED UPON THE ASSUMPTION THAT EACH PUPIL IN A CLASS OF 50 PUPILS KNOWS EXACTLY 90 TRUE-FALSE STATEMENTS ON A TEST OF 100 STATEMENTS, AND THAT EACH PUPIL GUESSES AT THE REMAINING 10 STATEMENTS WHEN THE DISTRIBUTIONS ARE CONSTRUCTED BY MEANS OF THE "f", "f-k", AND "c" METHODS, RESPECTIVELY

Score		Method "f"	"f-k"	"c"
1		2	3	4
98		4		
96		1	4	3
94		3	4	6
92		9	8	8
90		10	13	13
88		14	16	9
86		5	5	9
84		3		2
82		1		
Total		50	50	50
Range	Ext	82-98	86-96	84-96
	Dif	12	10	16

There is a greater difference in the extreme range of the three columns of this table than was the case with the preceding table However, the average of the difference of the extremes for this table and the average of the extremes for the corresponding columns of the preceding table agree very closely when all the factors influencing them are taken into consideration

The close agreement between the data contained in Tables 6-8 and Tables 4 and 5 should be noted

A significant fact which should be noted when all the tables of this section are compared is that the ratio of the difference in the extremes of the range tend to increase in an inverse manner as the proportion of the guessed statements to the total number of statements decreases

Conclusions

1 A unit factor of chance or a small number of unit factors of chance do not operate with any high degree of uniformity. In order for there to be any dependable-uniform degree of chance there must be a great number of units upon which this uniformity is based

2. The formula, rights-minus-wrongs-equal-score, does not approach uniformity in equaling zero for 100, 70, 40, 25, or 10 true-false statements if the persons taking the examination are innocent of *all knowledge concerning the statements included in the* test It follows from this that individual scores tend to be influenced by chance in proportion to the number of guessed statements on a true-false test This is definitely shown when all marking of a true-false test is done according to chance as was the case in determining chance by the "*f-k*" method of this study.

3 The safer method of scoring true-false tests is to eliminate chance by penalizing guessing to the extent that the person taking the examination will be compelled to mark only those statements which are definitely known to him The true-false examination becomes an accurate instrument for the measurement of achievement only when the chance factor is eliminated for every individual

4 The influence of chance cannot be reduced by increasing the *length of the test if it is scored according to the rights-minus-wrongs* method unless the ratio of known statements to guess statements is increased.

5 The factor of chance influences a high per cent of the scores

on a test in a definite way This problem should be given much consideration by educators It should not be assumed that because heads equals tails for 1,000 or 50,000 flips that the formula rights-minus-wrongs gives exact results for 10 or 100 true-false statements, when the persons taking the test guess in marking any or all of the statements.

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SHORT ARTICLES AND NOTES

The Journal of Genetic Psychology, 1938, **53**, 231-233

THE PERFORMANCE OF PRE-SCHOOL CHILDREN ON THE KOHS BLOCK DESIGN TEST*

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A paper by Eigler (3) concerning the achievement of pre-school children on the Kohs *Block Design Test* (5) reports that some of these children made remarkably high scores on the test. For example, one child, *CA*—3 years, 8 months, *IQ*—127, made a Kohs mental age score of 12 years, 1 month. Another child, *CA*—4 years, 7 months, *IQ*—100, made a Kohs mental age score of 12 years, 7 months. There were four such cases of remarkably high scores in the group of 29 children. Twelve children successfully completed one or more designs and 17 children failed the test completely.

These findings that some young children made such high scores, far in advance of their chronological and mental ages, are of interest in the light of the extensive use of the Kohs *Block Design Test* as a non-verbal test of intelligence and the recent application of the test in the study of the intellectual functions of neurological and psychiatric patients (1, 2). These considerations have led the writer to make further observations on the performance of pre-school children on this test.

A group of 30 pre-school children served as subjects in the present study.[1] Eigler's procedure, which is essentially that prescribed by Kohs (5, pp. 75-76) for use with subjects who do not know the

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[1]Most of the children who were used in this study were attending the Payne Whitney Nursery School. The writer wishes to thank Miss Florence Eaton, Director of the Payne Whitney Nursery School, for her helpful cooperation.

names of colors, was followed The only deviation from Eigler's procedure which was made in the present study was that the performances were scored according to the method of Hutt (4), in which only time, and not time and moves, is used as the basis for scoring. The test results are given in Table 1

TABLE 1

Subj.	Sex	*CA*	Binet *MA*	Binet *IQ*	Kohs *MA*	Specific designs successfully completed
W G	M	2-11	4- 7	157	——	——
S J	F	3- 1	3-10	124	——	——
S S	F	3 2	4- 7	145	——	——
C D	F	3- 8	4- 4	118	5-10	I
K P	F	3- 8	4- 6	123	——	——
L R	F	3- 8	5- 1	139	5-10	I
B L	M	3-11	4- 1	104	——	——
A M	M	3-11	4- 4	111	——	——
B D	M	4- 0	4- 1	102	7- 2	II, III
P S	M	4- 1	5- 4	131	5-10	I
C L	M	4- 3	6- 8	157	6- 5	II
D H.	M	4- 4	4- 6	104	——	——
M S	M	4- 4	5-11	137	5-10	I
C.H	F	4- 4	6- 5	148	7- 6	I, II, III
P K	M	4- 5	6- 1	138	——	——
B.M	M	4- 5	6- 3	142	6- 9	I, II
J D	M	4- 6	5- 3	117	7- 6	I, II
B.T	M	4- 8	5- 4	114	——	——
H M	M	4- 8	6- 3	134	5-10	I
C.H.	F	4- 9	5- 9	121	——	——
V V.	F	4- 9	6- 5	135	——	——
B D.	M	4-10	5- 4	110	——	——
P.V.	F	4-11	6-11	141	7- 9	I, II, III
F O	F	5- 0	5- 3	105	——	——
J C.	F	5- 3	6- 5	122	5-10	I
K F	F	5- 5	5- 2	95	——	——
H F	F	5- 5	5- 5	100	——	——
C.K.	F	5- 5	6- 8	123	6- 3	I
O G	M	5- 6	7- 6	136	6- 9	I, II
G D	M	5-11	7- 4	124	7- 2	I, II

It will be noted that 15 of the 30 children successfully completed one or more designs, a slightly greater proportion than that found by Eigler (12 out of 29 children). However, no such remarkably high scores as Eigler reported were found. The highest Kohs mental age score was 7 years, 9 months, and the greatest discrepancy between Binet mental age score and Kohs mental age score was 3 years, 1

month No child successfully completed more than the first three designs.

In short, with a pre-school group of comparable size and intelligence level, Eigler's findings with respect to the occurrence of extremely high scores is not confirmed This at least indicates that the frequency of occurrence of such high scores is not as great as Eigler's report would suggest.

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BOOKS

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CRITICAL REVIEWS OF RECENT BOOKS

(Murphy, Lois Barclay. *Social Behavior and Child Personality*. New York: Columbia Univ. Press, 1937. Pp. 333.)

Reviewed by Barbara S. Burks

Unusual interest attaches to an experimental report by a critic and interpreter of developmental psychology who has contributed as much as this investigator to the clarification and consolidation of the field. In 1930, one of the first to appreciate the importance of Russian work on children's social development, she was writing: ". . . Probably the chief significance of such studies is the dramatic demonstration of the way in which changes in the social order reflect themselves in the attitudes, the interests, and the social relationships of little children, the child grows *into* a society." At the same time, fully sensitive to the firmer quantitative control exercised in American work, and above all a champion of multi-dimensional approaches to the problem of personality structure, she was "discovering" and italicizing the studies of such original investigators as Berne, whose contemporary "Experimental investigation of social behavior-patterns in young children" she described as a "single-handed *tour de force*" in which ratings, experiments, and observational records were all used upon the same Subjects and their results compared through intercorrelations.

Since her major salute in the collaborative "Experimental Social Psychology," Murphy's brilliant series of summaries, reviews, and prospecti of educational implications have progressed steadily toward an ever more articulate position. The child-developing-in-his-culture concept has now become a richly elaborated formulation of particular pressures acting upon basic biological materials, all in a total cultural setting which determines not only the range of available responses, but also the meaning to the individual and hence the stimulus value of specific situations.

These ideas, however clear in their envisagement, prescribe an experimental research program fraught with enormous complexity. We are perhaps less arrested by the viewpoint itself, which sanely recombines some of the most reasonable and least bizarre tenets emerging from clinical psychiatry and anthropology, than by the striking proposal that such concepts could be subjected, even partially, to experimental verification.

In taking up the book, which is built upon sympathetic responses in young children, the reader will probably bring with him a deep *curiosity as to how far the frontiers* of experiment and controlled observation can extend, and to what degree clinical intuition or sophisticated conjecture will have to fill out the picture. He will find that in so far as objective research tools are available Murphy uses them, and that much ingenuity is employed in working out techniques of *recording observed episodes on nursery school play*-grounds, the rating scales used by nursery school teachers and observers for differentiating the Subjects of the study upon sympathetic behavior, and a host of related social traits, the "sociometric" analysis of individual rôles in group structure, and the framing of experimental situations which *would not ordinarily occur on the* playground The interesting variety represented by the framed situations could be appreciated only through an enumeration and description of all twenty odd, but for illustration a few may be mentioned here the "play-pen" experiment in which the Subject is left alone with a 24-months-old child who is confined in a pen out of reach of an array of attractive toys, the "fish" experiment in which the experimenter removes a small fish from a jar of water and gives the Subject an opportunity of having more withdrawn, story of a mother rabbit who ate up her little rabbits. Commenting upon these experiments, the author herself writes

> If the investigator were repeating the research at the present time, she would use the framed situation to the utmost to explore the variable and invariable aspects of each child's behavior Much valuable light on subjective aspects of this problem could have been gained from fuller analyses of responses to pictures, dolls, stories, clay, paper and paints

For the broad problem of relating the development of social behavior (including sympathy) to the culture as interpreted to the young child by his home and nursery school, and accepted by him in terms of "his previous experiences and his own special sensitivities or areas of awareness and understanding, anxiety and interest," there are of course no strictly objective techniques at present open to the author She is consequently thrown back upon the approach of the cultural anthropologist, the insight of the clinician. Her analysis of the institutionalized behavior in this culture, the theme of success, the keynote of "competitive individualism" in which

are rooted "both the drive for power and the obligation to pity" may reasonably impress most readers as wise and true. Her formulation regarding the immediate cultural pressures upon her main experimental Subjects, reached after one-hour home interviews with parents and prolonged observation of nursery school teachers, seems sound to this reader, at least.

Despite "physical and external similarities" in background, "internal and mental confusion and conflicts" arise as a result of stable characteristics of the culture that appear to be "contradictory in their strong aggressive and strong cooperative trends" (p. 47). Some of the most provocative hypotheses of the entire study come out of this formulation and the inferred influence upon the child's development of the necessity placed upon him "to sift out what is really dependable and important from the confused array of verbal and behavior patterns which different adults present." Some influences in the culture, and even in the physical situation, however, are sufficiently definite to make themselves clearly felt in a whole group of children. Various attitudes and procedures of the teachers, some of whom encouraged the older children's awareness of younger children's needs, others of whom encouraged independence or "laughed off" the hurts of the pupils, were related to the frequency and kind of sympathetic responses among the children. "Children in Group *W*, which had the narrower age range and smaller play space, showed fewer sympathetic and more unsympathetic responses . . . while Group *H*, which consisted of a group of older children and 'babies,' in a larger play space, showed more sympathetic responses and fewer unsympathetic ones." Child-to-child influences were illustrated by a "culture fragment" picked up by one child from another during the year until over half the group had made the response at one time or another (*"I'm a big boy. I don't cry."*), and by clinical accounts of one child's altered social patterns after a period of prolonged teasing by an aggressor, another child's growing socialization during her companionship with an outstandingly sympathetic child.

In considering personality "structure," the author finds slight evidence for well crystalized social "traits" at the nursery age level, although this does not imply "that other aspects of the child's behavior, more dependent upon the structure of the organism, such as tempo, gesture habits, amount of large-muscle and small-muscle

activity, rhythm, or coordination, would be so variable." While certain forms of sympathetic or aggressive behavior, or both, may be typical for individual children during a fairly long period of observation—some months or even a year—thus giving

> unimpeachable evidence of a "sympathetic trait," the behavior which constitutes this trait is dependent upon the functional relation of the child to each situation, and . . . when shifts in status give a basis for a changed interpretation of the situation in which the child finds himself, changed behavior occurs. A significant proportion of the variations in a child's behavior . . . are related to the child's security, as affected by competitive relations with other children, disapproval by adults, or guilt and self-accusation in relation to injury to another child (p. 191).

Among the most interesting of all the case notes were those on certain children who were more sympathetic when insecure, and less so when secure and happy in their group; others who were less sympathetic, more aggressive and defensive when insecure. These individual patterns are believed to be rooted in

> the individual's attitudes of group dependence, as compared with group dominance. . . . The individual who temporarily, or over a long period of time, is in a position of seeking approval of the group he confronts, is apt to have lowered thresholds for sympathetic responses to members of that group. . . . The individual who has been relatively sure of his dominance, on the other hand, may only fight harder in self-defense when his security is temporarily or for the first time threatened" (p. 182).

The "situational" determinants of sympathetic behavior were brought into clearest relief when the children's responses to the framed situations were aligned against their sympathy "scores" composed from episodes observed over months of time on the playground. Through a protocol analysis (which the author has not fully explained), it is concluded that about a third of the children showed behavior that was inconsistent from one experiment to the next; nearly the same proportion showed behavior on the experiments that was either inconsistent with or unpredictable from their observed playground behavior. Such inconsistencies in behavior as occurred would have greater empirical significance if something in

the nature of "reliability coefficients" of behavior in the single situations could have been secured. However, the author's analyses of the "inconsistencies" shown by particular children do provide explanations having so much clinical vitality that one is tempted to require any doubting Thomases to "show cause" why the explanations are not valid.

Perhaps the remarkable finding is not so much the inconsistency shown by a third of the children (or two-thirds?—the overlap of different groups is not clearly shown), as the consistency that *was* shown by a considerable number of these very young Subjects. Even bearing in mind that consistency, for Murphy, is not a criterion of a crystallized trait, since changes in personal status may bring about changes in the trait, any characteristic social behavior that persists even for a few weeks or months provides an excellent opportunity to examine it in a matrix of other expressions of personality. Such investigation is made in various ways—through clinical synthesis, through more objective individual "personality dials" of trait ratings and "scores" obtained in experimental situations, and through still more objective correlational studies. One of the most arresting outcomes, and one that is referred directly to the earlier discussion of the impact of conflicting adult values upon the child, is the positive relationship between sympathetic and aggressive behavior that emerged from the composite rating scales of playground activity. In three different groups the zero-order correlation varied between .24 and .54. In the group of 18 children for which the data were most amply reported, the zero-order correlation was .33, which became .27 when age was partialled out. "Cooperative" and "aggressive" behavior, on the other hand, correlated negatively to about the same degree (—.34 when age was partialled out). Striking correlations were reported between certain items of one of the three rating scales, and the total score on another scale. But in view of the small number of cases entering the correlations and the negative correlation between "cooperation" and "aggression," it is possible the author's hypothesis (p. 65) that "the more completely a child reflects [the] protecting-fighting culture, the more likely he will be to show both tendencies to a considerable degree" will have to undergo elaboration or modification as further evidence becomes available.

The data of the entire study are consistent in showing an in

crease with age of social behavior of all kinds—aggressive and defensive as well as sympathetic and cooperative When a qualitative rather than a quantitative analysis is made of the behavior records, the data suggest to the author (p. 166) a developmental sequence for sympathy in the "average child," viz (*a*) attention caught by distress (stares), (*b*) responds with comment or emotional expression; (*c*) *attempts to bring different feeling in child* (by comforting, etc), (*d*) attempts to alter or remove situation causing the distress

For C Buhler, or for Piaget, such sequences are equivalent to "stages," since both investigators define stages in terms of the *direction toward which* the child is developing Each admits that a child may belong simultaneously to different stages with respect to different stimulus situations. Piaget sees the stage at which a *child functions in a given situation* as determined by the readiness or difficulty with which its meaning can be placed into objective social perspective—this in turn depending upon the degree of the child's "egocentrism" defined in a special sense

Murphy takes a somewhat different viewpoint, and writes (p 272-3)

> The stage is probably not an intimate product of interaction *of maturation and learning, in the case of sympathy*, but a phase linked to circumstance at a given period There is *no "stage" of egocentricity, or of projection of anxiety in* pseudosympathy, or of direct response to another's need, or *identification with it* *An insecure adolescent is no less* egocentric than an insecure four-year-old An adult identifica*tion in love arouses no quicker nor purer feeling of shared* pain or joy than that of a responsive two-year-old

This statement regarding "stages," which seems to under-emphasize the qualitative age-correlated *differences in the experiencing of* sympathy suggested by the published protocols, probably connects with the author's conception of egocentrism, which she uses, up to the last chapter, in a different sense from Piaget's—rather in the sense of self-preoccupation instead of the self-oriented social perspective, the ill-discerned boundary between self and others, to which Piaget has attached the term. Although Murphy's sense is a legitimate one, Piaget's would seem more fruitful in the present investigation, and indeed in her final chapter Murphy actually swings into a discussion according to the Piaget framework A

-cut distinction is made between the earlier "contagious feel- and the more advanced "identification," which, however, in till egocentric small child may lead to the projection of anxieties n in the face of contradictory evidence from the adult's point iew." Of the latter, abundant examples from the published , and particularly from the excerpts of parents' diaries, could uoted, e.g., the introjective mechanism in Celia at 25 months, insisted that her mother remove her feet from the edge of oven, and in Patsy at 30 months, who must wipe the soap from eyes of the picture-book baby

rom here on the Piaget schema is not followed out to its full ications Emphasis is rightly given to the observation that "the social factors which are building egocentricity are also building lf which is apt to function or to fulfill itself in characteristic s" (p. 306) However, it is credible that a further analysis of material in terms of the "egocentrism" vector might lead quite pellingly into a formulation of developmental stages that de- led upon something more than phases "linked to circumstance given period" Do not the developmental sequence outlined by rphy, and the published excerpts from her protocols, suggest inishing steps of "realism"—a tendency at 3 to express sympathy erms of only partially assimilated adult patterns (e g, hugging, ng, patting), and often to translate sympathetic feeling into liative measures against another child's aggressor, superseded he most socially mature children by adaptive responses more iniscent of the spontaneous responses of the youngest of all than he more stereotyped behavior at intermediate ages?

lthough the oldest children among Murphy's Subjects were 4½ years old, their high average mental age and superior home kground undoubtedly "stepped up" their rate of advancement in al behavior. Another factor which might be expected to fix developmental sequence of sympathy in playground distress situa- s in an earlier age range than is usually found for other forms ocial behavior is the fact that situations calling for sympathy are isely those in which the needs of the other person are so vivid o compel recognition. Just as early experiences in competition, Isaacs' studies of social behavior, hastened the breaking down egocentric barriers by making the child objectively aware of his 1 ego-entity, so we believe early sympathy stimuli may bear a

complementary rôle in emphasizing the recognition of the separateness of other egos. We would want to make an analysis of Murphy's unpublished protocols, possibly supplement this by clinical interrogatory, and obtain observations upon older (school-age) Subjects before proposing such a schematization of "stages" with any urgency. But the formulation of true developmental stages in sympathetic feeling and behavior meanwhile remains a tantalizing possibility.

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Child Behavior, Animal Behavior, and Comparative Psychology

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CARL MURCHISON

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VISUAL DISCRIMINATION IN THE CAT VI THE RELATION BETWEEN PATTERN VISION AND VISUAL ACUITY AND THE OPTIC PROJECTION CENTERS OF THE NERVOUS SYSTEM*

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KARL U SMITH

A INTRODUCTION

Throughout the past fifty years many attempts have been made to assign different visual functions to different pathways and nuclei in the nervous system An early hypothesis of this sort, one which arose particularly from the work of Munk (15) and Minkowski (13), assigned all vision to the optic projection areas of the cerebral cortex, and certain visual reflexes to subcortical centers Another more recent view, which was first suggested by the work of Lashley (9) and of Lashley and Frank (11) on the rat and later extended by the studies of Marquis (12) and Kluver (7) on the dog and monkey, assumed that the mediation of intensity discrimination could be carried out by subcortical optic centers as well as those located in the cerebral cortex. According to this theory, however, pattern vision and visual acuity, and all other optic functions except a primitive type of "light" vision, depend upon the arrival of impulses in the projection areas of the cerebral cortex

These two general ideas of the functional importance of the cortex in vision have not been supported by the results of still later investigations Lashley (10) has recognized, for example, the inadequacy of the belief that there is strict division of the functions of pattern vision and intensity discrimination with respect to their determination by the cortex and by the primary optic centers He states that the ability of rats to discriminate on the basis of the position of lights after destruction of the cerebral cortex necessitates assuming a crude sort of detail vision in these animals

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Additional experimental findings from several different sources all point to certain modifications of the view that pattern vision and hence all degrees of visual acuity are exclusively dependent upon neural pathways passing to the cerebral cortex. Van Herk and ten Cate (5) have shown that rabbits, after destruction of the cortex, recover to a certain degree the ability to respond to objects held or moved in the field of vision. A somewhat similar type of primitive pattern vision has been shown by Kennedy (6) to exist in cats after cortical extirpations which included both optic projection areas. In these studies, Kennedy found that the operated animals could discriminate to some degree between simple moving and non-moving stimuli such as bars and dots.

Besides the observations just quoted, the investigation of forced optokinetic reactions of the head and eyes to moving visual patterns after destruction of the cortical visual centers in different mammals has disclosed the presence of discrete pattern vision mediated exclusively through subcortical centers. The present writer (17, 20) has observed that such responses occur in cats after extensive destruction of occipital cortex involving the striate areas as well as surrounding tissue. Ter Braak (3) has noted similar responses in rabbits, dogs, and monkeys lacking the visual centers of the cortex. The occurrence of the reactions in the absence of cortical connections in these different forms seems to indicate that there are no marked phylogenetic differences in the degree to which the striate areas have become related to the forced orientations of the head and eyes to changes in visual pattern.

It is clear from these results that the primary optic centers of the thalamus and midbrain play a definite part in controlling certain limited types of pattern vision. In consequence of the fact that the optokinetic responses constitute true differential orientations to changes in the patterned characteristics of visual stimulation, and at the same time occur in the absence of the striate areas, it is possible to utilize these reactions in a functional analysis of the rôle of the subcortical optic centers in the determination of the various visual capacities involving form or detail vision. Preliminary reports of such study have already been given, in which the relations of visual acuity (18), fusion of real movement (2), and apparent-movement vision (21) to centers located below the level of the cortex have been brought out.

B. Problems

Although the different observations just cited bring forth definite proof that there are residual types of pattern vision, visual acuity, and real- and apparent-movement vision after elimination of the cortical pathways of the optic system, detailed description of these subcortically controlled visual functions must be secured. In particular, it is important to know whether the pattern vision associated with optokinetic reactions is comparable to that which may be demonstrated by discrimination methods. With this problem in mind, the writer presents here data obtained with cats lacking the striate cortex relevant to (*a*) their ability to discriminate between two simple line figures, (*b*) their capacity to respond to rotating striated patterns of different widths.

C. Animals and Operations

The experiments involved the use of five normal cats and three in which the occipital lobes were removed. The operations were all done in one stage under Nembutal anaesthesia. The occipital cortex was exposed through an opening in the cranial cavity under the temporal muscle, and the lateral and splenial gyri, together with surrounding tissue, were dissected out in one block. The extirpated tissue was immediately fixed in formalin for future examination. The wound was then securely closed by suturing the temporal muscles and overlying tissues, after which the animals were allowed two weeks to recover from the operation. Learning and acuity tests were then begun and continued for some six months after the operations.

D. Anatomical and Behavioral Controls

Judgment as to whether or not the striate cortex was completely removed rests upon five criteria: (*a*) examination of the extirpated blocks of cortical tissue, (*b*) gross examination of the cortical lesions, (*c*) reproduction of the cortical lesions from projection drawings of the stained slides of the brains, (*d*) histological investigation of the external geniculate bodies, (*e*) observation of typical defects of vision which are known to accompany complete bilateral destruction of the visual connections with the striate areas.

After the learning and acuity tests had been carried out with

FIGURE 1
The Brain of Subject 42

the operated animals, they were immediately killed and the brains perfused with 10 per cent formalin through the aorta Following removal of the brain from the skull cavity, a block containing the lesion was sectioned from the rest of the brain and thereafter prepared for cutting and staining It was imbedded in celloidin and cut into sections 35 microns in thickness. Every fifth section through the block and every other section through the external geniculate body were then stained in thionin.

In Figure 1 is shown a photograph of the brain of one of the operated animals. The operation performed on this animal is typical of those carried out with the other two subjects As seen in the plate, the operation performed involved removal of the cortical tissue contained within the first two external convolutions, the lateral and ectolateral gyri In all cases the lesions extended well beyond the posterior termination of the lateral sulcus and forward to the boundaries of the sensory-motor cortex In the region of the lesion, there was no cortex remaining along the medial sides of the hemispheres of Subjects 40 and 41, but in Subject 42 a small fringe of cortex was still present in this region The ventricles were opened along the greater extent of the lesion in all three animals

Figure 2 presents diagrams of the extent of the lesions on the lateral and medial sides of the brains of the three subjects as constructed from large drawings of stained sections As seen in these diagrams, the cortical destruction extended beyond the medial and lateral limits of the striate areas, i e, the lateral sulcus on the dorsal aspect of the hemisphere and the splenial sulcus on the medial side The posterior terminations of both the lateral sulcus and splenial sulcus were included within the extirpations in the three cases Anteriorly, the lesions all extended beyond the posterior lateral gyrus In the case of Subjects 40 and 41, examination of the sections showed, as did also gross examination of the brains, that cortex lying medially in the region of the lesion had either been removed or had degenerated A fringe of cortex which did not include any of the splenial sulcus along its length was still intact medially in the region of the lesion in the brain of Subject 42.

The sections taken through the external geniculate body in the three different animals were closely examined for the presence of ganglion cells Such cells of typical size and form could not be

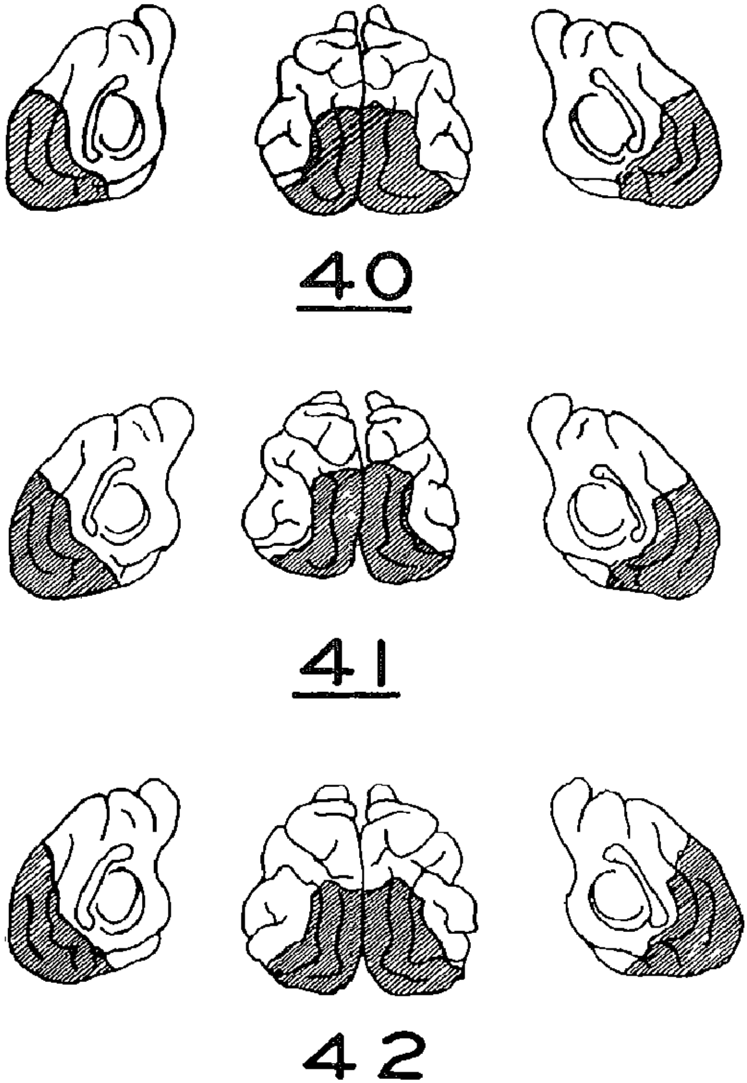

FIGURE 2

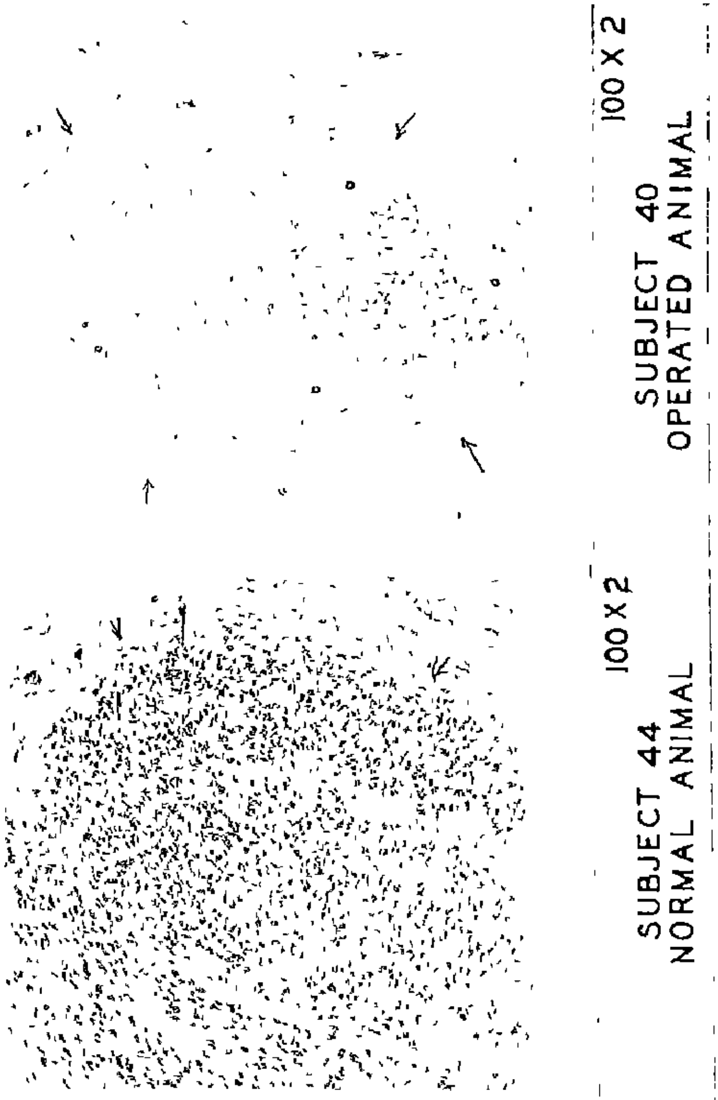
SUBJECT 44
NORMAL ANIMAL
100 X 2
SUBJECT 40
OPERATED ANIMAL
100 X 2

FIGURE 3

discovered in any of the sections Median sized cells, showing pathological characteristics as compared to the ganglion cells of the external geniculate body in the normal animal, could be found distributed at infrequent intervals throughout the nucleus in all three brains, but these were never equal in size and density to the large cells of the normal nucleus.

For purposes of illustration, in Figure 3 are compared photomicrographs of sections through the external geniculate body of a normal cat and that of one of the operated animals (Subject 42) used in the present experiments. Both pictures were taken at approximately 100 diameters magnification and enlarged two times in printing The section through the brain of the normal animal was cut at 50 microns, that of the operated animal at 35 microns. The boundaries of the external geniculate body are marked by arrows. Reference to the plate will show the nature of some of the histological changes, particularly the absence of the large ganglion cells of the nucleus in the operated animal, which are brought about by removal of the striate areas in the operated animals, as already described above

Subjects 41 and 42 possessed small lesions of the right superior colliculi, which were definitely the result of the operations. These lesions extended over approximately one-fifth of the superior portion of the colliculi on the right side Other than this, there were no other marked discernible cell changes in the colliculi of the three animals

The visual placing reactions of the forelimbs, the ability to avoid obstacles and to find food, the responses of the eyelids to movements of the experimenter, the reactions to objects moved or held in the field of vision, the responses made in attempts to descend from elevated surfaces, were all examined in the three animals after the operations had been carried out. The fact is known from the work of prior experimenters (Munk, 15; Minkowski, 13; Marquis, 12) that these reactions are permanently absent after complete bilateral destruction of the cortical centers of vision. Repeated observations on the animals employed in the present study demonstrated that these reactions could not be elicited during the period of some six months that the animals lived subsequent to the time of the operations

E. Methods and Results

As outlined above, the present investigation is concerned with the effects of complete extirpation of the striate cortex upon two different aspects of visually determined behavior. The first part of this section is concerned with the ability of the operated cats to learn a simple pattern discrimination habit. In a second part, the nature of the visual acuity of the cats in responding to rotating striated patterns will be described.

1. *The Effect of Removal of the Striate Areas upon the Learning of a Simple Pattern Discrimination Habit.* This investigation of a type of simple pattern vision utilized a discrimination apparatus previously described by the writer (16). The device consists of two small discrimination boxes, 28 cm. wide, 29 cm. long, and 33 cm. high, which are each arranged with small doors on their front sides. Either of these doors may be opened by depressing a small lever located near the bottom of each box. In the front side of the doors are grooves into which ground optical glass or cards bearing visual patterns may be quickly inserted or removed. The doors are held tightly closed by spring latches to which are attached the brass levers of the boxes. A master latch, mounted near the top of the door of each box can be used to prevent the door from being opened even though the lever is depressed.

The cat responds to the situation by depressing the lever on one of the discrimination boxes, which causes the door of the box to swing back, and permits the animal to secure a small piece of salmon placed inside the apparatus. When discriminating between stimuli presented in the doors of the boxes, the animal is rewarded by thus obtaining food. It is punished for a wrong response by failure of the door of the box to open and by electric shock, which is administered by leading an electric current through the lever and suitable conducting grills placed immediately in front of the discrimination boxes. The electric current giving the shock may be shifted from box to box by means of a double-throw switch.

The two discrimination boxes are placed at the end of a long runway table so that their front sides face a restraining cage located at the other end of the table. The animal is released from this cage, allowed to approach the discrimination boxes at the other end of the table, and respond to stimuli presented in the doors of the boxes. When it has received food either as a result of making

a correct response or after it has received punishment and then responded to the correct box, the cat is returned immediately to the restraining cage for another trial Between trials the stimuli presented in the doors of the discrimination boxes are changed in position in chance order.

The stimuli used in the experiment consisted of a horizontal bar, 2 5 cm wide and 18 cm long, and a vertical bar of the same dimensions The bottom of the vertical bar was approximately 10 cm. from the floor of the runway table, while the horizontal bar was elevated 18 5 cm above the table The centers of the two stimuli were separated by a distance of approximately 48 cm The stimuli themselves were secured by inserting black cards, having apertures of the size of the bars described above, into the doors of the discrimination boxes Ground glass screens were placed behind these cards so that the stimuli appeared as two uniformly illuminated bars oriented respectively in a horizontal and in a vertical plane. The glass was illuminated by two enclosed projection systems, one located directly behind each of the discrimination boxes

A large black panel was located near the front of the apparatus in such a way that only the doors of the discrimination boxes could be seen by the animal from its position on the runway table. The use of this screen and the enclosed projection systems provided a black background for the two luminous stimuli During observations no other lights were used in the experimental room

The three operated animals and three normal cats were used as subjects in the experiments They were first trained in the habit of depressing the levers in order to secure food, and thereafter presented with the training stimuli Since two of the operated animals (Subjects 40 and 41) had been used in other discrimination experiments involving the same type of apparatus, these animals did not require preliminary training in depressing the levers before the stimulus patterns were presented

In Table 1 the results obtained in the attempt to train the three normal and the three operated animals in the discrimination of simple bar patterns are summarized with respect to the percentage of correct responses made by the cats in the daily 10-trial periods This is the amount of training given each subject each day. The numbers in the table represent the percentage of correct choices of the vertical bar, which was employed as the positive stimulus.

TABLE 1

THE PERCENTAGE OF CORRECT RESPONSES MADE BY NORMAL AND BY OPERATED ANIMALS DURING CONSECUTIVE 10-TRIAL PERIODS DURING THE LEARNING OF A SIMPLE PATTERN DISCRIMINATION HABIT

	Normal animals			Operated animals		
Trials	53	54	55	40	41	42
0- 10	40	30	30	50	60	50
10- 20	60	40	60	50	40	50
20- 30	60	60	50	40	40	60
30- 40	50	60	60	70	50	50
40- 50	60	50	40	70	40	50
50- 60	60	70	60	60	60	50
60- 70	40	80	70	40	30	50
70- 80	70	100*	80	50	60	70
80- 90	80	90	80	70	50	60
90-100	60	90	90*	50	60	60
100-110	70	80	90	70	70	80
110-120	80	80	80	40	60	60
120-130	80	80	90	60	50	60
130-140	90*	90		60	80	50
140-150	90	90		80	70	60
150-160	80	80		60	50	50
160-170	90	100		70	90*	50
170-180	100	90		50	60	70
180-190	80	100		60	40	60
190-200	100			80	40	50
200-210	90			60	60	70
210-220				70	50	80
220-230				70	70	50
230-240				90*	50	50
240-250				90	60	70
250-260				90	70	60
260-270				80	70	50
270-280				90	60	70
280-290				90	80	50
290-300					60	60
300-310					90*	
310-320					70	
320-330					70	
330-340					60	
340-350						
Criterion of learning fulfilled	140	80	100	240	(170)	—

Reference to this table will show that the normal cats were able to discriminate in 9 out of the 10 daily trials after periods of training covering, respectively, 140, 80, and 100 trials The choice between the two bars seemed extremely easy for these animals, particularly

Subjects 54 and 55, and when they once learned, the habit remained relatively stable with continued presentation of the stimuli. Only two of the operated animals, however, were able to reach 90 per cent correct choice of the two patterns in 10 trials, and Subject 41 demonstrated this capacity only twice in the 340 trials of training The responses of the operated animals, in contrast to those of the normal cats, were highly unstable, i e, although giving evidence of differential behavior in one series of trials, the operated cats would not make a significant number of correct choices on succeeding days. All three operated animals displayed indications of a significant number of correct responses during the second hundred trials of training but they failed in every case to maintain this level of discrimination on two consecutive days Of these three cats, Subject 40 was the only one which seemed able to distinguish between the bars with any degree of consistency, and then only after 240 trials.

Because of the extreme variability of the other two operated animals in responding to the patterns, Subject 40 was the only one which could be used in making control observations of the validity of the discriminative responses observed Elimination of the electrical shock over an entire trial period, and, in a consecutive period, decrease in the intensity of the vertical bar by approximately 50 per cent did not disturb the responses of the animal. Placing two horizontal or two vertical bars in the apparatus brought the percentage of correct choices of this cat down below a chance level. Furthermore, the method used provides for the elimination of secondary influences which may enter to furnish clues for differential behavior. Olfactory influences are controlled by keeping food in both boxes. There are no possible auditory clues from the experimenter since the animal itself performs all of the necessary operations in reaching the food. There is little possibility that the animal can discriminate on the basis of brightness differences in the patterns, for the stimuli were shifted between the two boxes independently of the light systems No discriminable differences existed between the size of the two patterns, and care was taken in changing the position of the stimuli in the boxes between trials so that no indications would be given as to the location of the positive stimulus before the animal was released from the restraining cage

2. *The Effects of Extirpation of the Striate Areas of the Cortex*

upon Visual Acuity in the Cat as Indicated by Optokinetic Responses

In the second part of the experimental investigation, the problem of pattern vision in cats lacking the striate areas was approached somewhat differently. A specialized measure of pattern vision, visual acuity, was used as an index of the capacity of the operated cats for resolving visual detail, or pattern. A relatively simple method for measuring visual acuity is to elicit optokinetic responses to striated patterns of different widths.

The apparatus used has already been described by the writer (Smith, 17, 18, 20). As used in the present experiment, this apparatus consists of a large cylindrical drum, 122 cm. in diameter and 110 cm. high, the inside circumference of which may be covered by alternate black and white lines of equal width. The drum is so constructed that it can be rotated independently of the animal, when the latter is placed in a box holder and located upon a small platform at the center of the drum. The cylinder itself is a wooden framework, the side of which may be covered with cloth or any other uniform material. The inside of the apparatus is illuminated by two 200-watt bulbs, one located above the cat's head at the top of the cylinder and the other below the platform on which the box-holder rests.

The top of the drum is left open so that the animal, restrained in the box-holder, may be lowered inside the drum by means of support rods attached to the ceiling. During observations, the animal is lowered to a point about 75 cm. below the level of the top of the drum and the head fixed at a distance of 50 cm. from the striated patterns. The drum is then rotated slowly by hand at a speed of about three revolutions per minute. In making observations of the animal's responses to the rotating lines, the number of pursuit movements of the eyes during one complete revolution of the cylinder are counted. The drum is then rotated in the opposite direction and the number of responses again noted. This procedure is repeated 10 times with each animal for each series of lines used in the experiment, for a total of 20 different trials.

Four series of striped patterns, which contained lines 5.0 cm., 2.5 cm., 0.6 cm., and 0.16 cm. in width, respectively, were used in the experiment. The first three series of lines were obtained by placing black cardboard stripes of the appropriate size against a white uniform covering on the drum. The finer lines were

secured by mounting cloth printed with alternate black and white stripes upon the side of the cylinder In each case the side of the drum presented a series of alternate, parallel black and white lines of the same width The brightness of the striped patterns varied somewhat at different points on the side of the drum from an average of approximately 12 millilamberts, a value which did not differ by more than one-half log unit for the separate series of lines used The brightness difference between the black and white stripes of the drum varied between 1 5 and 2.0 log units.

The responses of the three animals lacking both striate areas of the cortex were observed during 20 revolutions of the drum with each series of lines In addition, the responses of two normal animals (Subjects 57 and 59) were examined for comparison with the operated animals

Table 2 presents the average number of responses occurring per

TABLE 2

THE AVERAGE NUMBER OF RESPONSES PER TRIAL IN OPPOSITE DIRECTIONS OF ROTATION OF THE DRUM WITH THE DIFFERENT SERIES OF LINES

Width of lines	Visual angle	Subject 40 *R*	Subject 40 *L*	Subject 41 *R*	Subject 41 *L*	Subject 42 *R*	Subject 42 *L*
5.0 cm.	360 min	19	14	20	15	24	13
2 5	175	23	16	23	26	18	21
0.6	43	28	27	24	24	32	28
0.16	11	22	30	18	22	22	24

trial in 10 different rotations of the striped patterns in opposite directions. The width of the lines in the different striped patterns is given toward the left In the next column are found the values of visual angle corresponding to the lines of different width when the animal's head was placed at its position 50 cm away from the side of the cylinder. The numbers appearing in the first column under the number of each subject indicate the average frequency of eye movements when the drum was rotated toward the right, while those in the second column give the average number during rotation to the left.

Reference to the table will show that all of the subjects gave consistent responses to all of the moving striated patterns. In general, the number of responses per trial increased somewhat as the lines were reduced in width There are no marked differences

in the number of eye movements elicited toward the left and toward the right, even in the case of the two animals (Subjects 41 and 42) which had lesions of the superior colliculi No significant differences in frequency of response were found for the three members of the group.

The narrowest lines used in this series of observations can be taken tentatively as indicating the limit of visual acuity (minimum separable) in cats lacking the cortical areas of the optic system. The visual angle corresponding to these lines is approximately 11 minutes of arc However, the actual maximum acuity of vision in responding to patterns of this sort has not been determined because of the difficulty in securing uniform patterns of alternate black and white lines smaller than 0 16 cm in width[1]

Observations of two normal animals also showed that forced optic nystagmus could be elicited with the different lines used in testing the operated animals The apparent frequency and amplitude of the movements in normal animals seemed to be no different from that noted in the cats lacking the visual cortex However, difficulty is encountered in securing an accurate count of the number of responses of normal animals in this situation because of the presence of frequent head movements and also because the normal cat can fixate objects outside the drum It is known from other studies (Bojar, 2) that the recorded reactions of the eyes in normal cats and in cats lacking the striate areas show no significant differences in respect to frequency and amplitude of movement at a given speed of rotation under these general conditions of stimulation.

Besides the eye movements observed during rotation of the drum, head nystagmus and other reactions made by the animals were also noted Not infrequently, head nystagmus movements of small amplitude could be observed in the operated cats These were very rarely observed in the case of the normal animals. In addition, operated animals, as well as normal animals, portray rather frequent emotional reactions, e g , crying-out, rage, and attempts to

[1]In a further investigation of the acuity of the operated cats, a preliminary report of which has been given [Smith, K U The visual acuity of cats in the absence of the optic projection areas of the cerebral cortex *Psychol. Bull* (In press)], it has been found that they have a minimum visible acuity of at least 0 5-0 7 minutes of arc Inasmuch as three of the subjects of this experiment are still alive, the anatomical observations of the operative lesions have not as yet been carried out

escape from the box-holder, during rotation of the drum. Reactions of this sort are undoubtedly the result of stimulation by the moving striped patterns for the animals never show such responses when they are merely placed in the box-holder, unless they are so restrained for long periods of time

F. Summary and Discussion

In the present study two different series of observations were made as to the nature of responses determined by visual pattern stimulation in cats when the striate areas of the cortex are removed. Evidence was offered that the operations carried out on three animals involved complete extirpation of these areas, and that, therefore, the visual capacities of the animals must be a function of the subcortical optic centers. It is believed that the results found, when interpreted in an objective manner, have an important bearing upon questions raised early in the paper concerning the anatomical basis of pattern vision and visual acuity

The observations made leave no doubt that, under certain circumstances of stimulation, cats lacking the cortical mechanisms of vision are still able to display differential orientations of the head and eyes to moving visual patterns which subtend a visual angle of at least 11 minutes of arc This unexpected degree of visual acuity in the absence of the optic centers of the cortex compares favorably with the demonstrated minimum separable acuity of certain normal mammals, e.g., the pigmented rat, which Lashley (8) has shown to be able to discriminate between striped patterns subtending a visual angle of 26 to 52 minutes of arc. It is known that the minimum separable acuity of normal cats in the discrimination of alternate black and white lines is approximately twice as good as that shown here for the operated animals (Smith, 19). The acuity of the cats used in the present study may also be compared to a minimum visible acuity of 45 to 1.17 minutes of arc which has been shown to exist in normal animals when they are required to discriminate between the direction of single black lines (Smith, 19). But there is no doubt that the minimum separable acuity of the operated cats in the situation eliciting optokinetic responses is somewhat greater than that demonstrated. Since finer lines could not be secured in ascertaining the actual threshold of resolution of the patterns used, further experiments involving somewhat different types of stimuli

must be made in order to gain an exact index of the acuity of these animals.

The results of the observations show, nevertheless, that a high degree of visual acuity may exist in cats in the absence of the striate cortex and that the subcortical optic centers play some rôle in the determination of certain types of pattern vision The level of acuity found in the operated cats permits the assumption that these centers are differentiated to a degree not previously indicated in psychological or physiological investigation

There is every reason to believe that the functional acuity existing in connection with the optokinetic reactions involves what may be called "vision" in an objective sense of the word In the first place, the responses of the operated animals to the rotating patterns used do not consist of anything which can be called an isolated "reflex" as this term is ordinarily used, but involve rather differential orientations of the head and eyes to the moving stripes. In fact, the total response of the cat when unrestrained in this situation consists also of orientation of the whole body in the direction of the moving lines Besides these differential reactions, stimulation by moving patterns of the sort used in the present study gives rise to certain accessory emotional responses which duplicate in form if not in intensity those found in normal animals. It should be pointed out also that the characteristics of the optokinetic reactions in cats lacking the striate areas of the cortex are known to differ in no marked way from those of normal animals in respect to their frequency and amplitude under conditions of stimulation of the sort used here (Bojar, 2).

It is evident, of course, that pattern vision of the type demonstrated here in connection with the optokinetic reactions is different from that existing in relation to learned orientations and similar types of differential behavior. But this fact does not alter the present conclusion that a refined sensitivity in pattern vision may be mediated through subcortical optic centers in the absence of the visual projection system of the pallium Any description of the neural mediation of the differential behavior involved in learned pattern discriminations must take into account the capacities of every part of the visual projection system for the resolution of detail.

The first part of the reported investigation deals more specifically with the problem of learned orientations to visual patterns The

results obtained in the attempt to train the three normal and three operated animals in a habit involving simple pattern vision showed that cats lacking the visual areas of the cortex may possess a limited ability to distinguish patterns which differ rather greatly in their spatial distribution. The capacity of cats to learn this discrimination after destruction of the striate areas is definitely retarded, although probably not completely abolished. As was shown in Table 1, Subjects 41 and 42 never attained the stage of consistently correct performance in responding to two bar patterns. However, it is more significant that Subject 40, with a cortical lesion as complete as those of Subjects 41 and 42, finally learned the simple pattern discrimination, as shown by its consistent performance after 240 trials. It is possible that the differences found among the animals in learning the habit can be accounted for in terms of the collicular lesions produced in the latter two cats.

The question may be raised as to why previous experimenters (Lashley, 9, Lashley and Frank, 11, Marquis, 12, Kluver, 7) have failed to find evidence of discrete sorts of pattern discrimination after elimination of the cortical mechanisms of vision.[2] It seems to the writer that this fact may be explained in terms of the complexity of the patterns used in previous studies of this kind. The luminous bars used in the present investigation involve a greater difference in spatial distribution of light than can be obtained with other visual patterns of equal area. Furthermore, prior experiments on the effects of removal of the cortical visual centers on pattern discrimination have made use of stimuli presented under high illumination of the surround. The fact is known that cats lacking the visual cortex are unable to distinguish differences in intensity under conditions of high general illumination, such differences as are easily discriminable under lower illumination of the surround (Smith, 22). Undoubtedly the nature of the surround is as important in pattern discrimination of operated cats as it is in intensity discrimination.

In general, the results of this investigation have a definite bearing upon questions raised earlier in the paper as to the relation of visual acuity and pattern vision to the optic centers of the cortex and to those of the thalamus and midbrain. The results of both

[2]Lashley has since reported (Symposium discussion, A. A. A. S., 1936) isolated cases of pattern vision in rats lacking the visual cortex.

parts of the investigation indicate that pattern vision may be mediated in the absence of the cortical centers In addition the study of the optokinetic reactions in the operated cats provides a basis for the assumption that the visual centers of the superior colliculus and the pretectal region constitute a mechanism for the resolution of impulses which approximates the refinement of operation of the cortex itself

In the past, much attention has been given by anatomists to the nature of the projection of the retina upon the cortex, and the importance of the orderly arrangement of visual fibers as they invade the layers of the pallium has been greatly emphasized by them as fundamental to detail vision In contrast to this, the few facts that are known about the projection of retinal fibers upon the pretectal region and superior colliculus (Lashley, 10, Barris, 1, Minkowski, 14, Brouwer, 4) in different animals have not been discussed in the same way in regard to pattern functions, although experiments have indicated a high degree of organization of these nuclei with respect to the retina The present study indicates a functional significance for the anatomic complexity of these subcortical optic centers and for their local differentiation in relation to the areas of the retina

It seems clear from the data presented here that the theory of the functional projection of neural "figures" upon the striate region of the cortex as the sole basis for pattern vision and visual acuity has greatly over-simplified the actual operation of the nervous system in the determination of these capacities There is undoubtedly a much more complex integration of neural impulses arising from retinal stimulation in the determination of pattern vision, especially to moving stimuli. An answer to some of the puzzling relations involved in this complexity seems possible through further research along lines indicated by the present investigation

G. Conclusions

1 The presence of optokinetic responses of the head and eyes in cats after the cortical centers of vision have been destroyed makes possible the analysis of the rôle of subcortical mechanisms in the determination of different visual functions based on pattern vision.

2 Tests of visual acuity made on three cats after extirpation of the occipital lobes showed that these animals are capable of respond-

ing to moving striated patterns subtending a visual angle at least as small as 11 minutes of arc Although this degree of minimum separable acuity compares favorably with that of some normal mammals such as the pigmented and albino rat, it is somewhat poorer than both the minimum separable and minimum visible acuity which has been demonstrated in normal cats by means of discrimination methods Under the conditions of testing used here, the visual acuity of normal cats was found to be also at least 11 minutes of arc More refined determinations of the capacity of the animals could not be made because of difficulty in securing patterns of narrower lines

3 Observations made on the discriminative ability of three normal cats and the three cats lacking the striate areas of the cortex showed, in general, that the operated animals may retain some residual capacity in pattern discrimination. Apparently, removal of the visual cortex definitely retards the learning of such discriminations even though the patterns used are of the most rudimentary sort Reasons why previous investigators have failed to find evidence for such discrimination in mammals after cortical operations involving the striate areas are presented.

4 The visual acuity of 11 minutes of arc demonstrated in the operated cats tends to show that a heretofore unknown type of refined vision may be mediated through subcortical optic centers. Although these centers seem sufficiently differentiated in order to mediate certain rudimentary learned orientations based on pattern discrimination, the present results would tend to show that their organization in respect to these functions is not nearly so great as it is in connection with the pattern functions of the optokinetic reactions But further study must be carried out before precise answers to such questions can be given.

5. It seems fair to say that the results of the different parts of the present study combine to prove that previous theories concerning the anatomical basis of visual acuity and pattern vision in the nervous system have greatly oversimplified the actual operation of the centers in the determination of these functions Rather than being entirely dependent upon the projection of configurations of neural activity upon the striate areas of the cortex, as previous theories have maintained, pattern vision and visual acuity also seem to have a physiological basis in local differences in nerve impulses

mediated through the primary optic centers of the thalamus and midbrain In fact, the results found here, especially those dealing with the visual acuity of the cats without visual cortex, give a functional explanation of the refinement of organization of the subcortical centers of vision

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LETTER CONSCIOUSNESS OF BEGINNERS IN READING*[1]

Hunter College, and the Horace Mann School of Teachers College

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This report is one of several resulting from a study of reading progress in the kindergarten and primary grades carried on in the Horace Mann School, Teachers College, during the past four years. The study has indicated the basic importance of certain letter abilities in the mastery of the mechanics of reading. This paper gives further evidence of the natural early and extensive attention young children give to the form and sounds of letters in a progressive type of school.[2]

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[1]The study was carried on under the supervision of Dr. Cecile White Flemming, Director of Pupil Individual Development and Guidance, and of Dr. Rollo T. Reynolds, Principal. Prepared with the assistance of the U. S. Works Progress Administration, New York City, project No. 65-97-295, sub-project No. 25.

[2]The average mental age and intelligence quotient for each of these fourteen groups which contributed to the study, as measured by the Stanford-Binet Intelligence Examination are shown below. These measures are recorded as of January 1, or mid-year for each group.

	Average Mental age	Intelligence quotient
Four-year-old Kindergarten 1935-36 Number pupils 21	5.5 yrs.	122
Five-year-old Kindergarten 1934-35 Number 54	6.7	120
Five-year-old Kindergarten 1935-36 Number 48	6.6	120
Grade I		
Class Group *G*-1, Number 31—1934-35	7.8	119.7
F Number 28—1934-35	7.7	120.9
Class Group *G*-2, Number 26—1935-36	7.8	120.9
A Number 25—1935-36	8.1	132
Grade II		
Class Group *D*-1, Number 30.1—1934-35	8.8	121.7
E-1, Number 25 —1934-35	8.4	116
D-2, Number 28 —1935-36	8.9	121
E-2, Number 24 —1935-36	8.9	120
Grade III		
Class Group *H*, Number 29 —1935-36	10.0	120
I, Number 28 —1935-36	9.5	118

A. Reading Words

Table 1 shows the results of individually testing 42 five-year-old kindergarten children with 16 exercises of the Gates Primary Reading word recognition test. The words of the test are selected in

TABLE 1

Responses of Five-year-old Kindergarten Pupils on 16 Exercises of the Gates Primary Reading Word Recognition Test ($N = 42$)

Exer. No	Percentages: Correct	Most like	Less like		Test words: Correct	Most like	Less like	
1	40	12	12	10	drum	draw	there	grass
2	26	17	26	7	pie	pan	by	there
3	31	26	7	5	paper	paint	dress	robin
4	24	29	12	7	tail	take	wolf	ship
5	29	26	14	0	bat	boy	arm	cow
6	33	12	19	5	bread	broom	grass	drink
7	26	19	19	5	shoe	show	talk	wash
8	29	12	10	7	plant	paint	watch	house
9	17	29	12	7	door	dogs	corn	wish
10	36	5	17	2	feet	fire	doll	city
11	12	19	5	17	wolf	work	wood	talk
12	33	7	2	10	ship	shoe	stop	lip
13	21	21	2	7	rope	read	ride	hop
14	12	26	2	19	money	monkey	mouse	name
15	7	24	10	14	gate	garden	grow	wish
16	5	17	19	12	raining	riding	hiding	rooster
Total 16	381	301	188	134				
			Ave 161					

such a way that one wrong word of each set of four is more like the correct word than are the other two The table gives the percentages of responses by the pupils for each word of the 16 exercises. The first column shows the percentages of answers that were correct. The second column gives the percentages of wrong answers which were most like the correct word The third and fourth columns show the percentages for each of the other two wrong words. The four columns of words on the right hand part of the table are, respectively, the correct, the most like and the less like wrong words. The totals show that the wrong words most like the correct words totaled 301 and those for the other wrong words 188 and 134, each, or an average of 161. That is, the children tended to select the most like words about twice as frequently as either of the other wrong words.

Exercise by exercise the most like words had a higher percentage of choices than the others 8 times out of the 16, and the same percentage three times In five exercises one of the other wrong words had a higher percentage than the most like ones. One of these was Exercise 2, in which the wrong word *by* was indicated by 26 per cent, while *pan* (the most like wrong word) as chosen by 17 per cent It is obviously an open question which of the wrong words, *pan* or *by*, is really more like *pie*. *Pan* was selected by the writer because of its initial likeness Initial likenesses seemed much more apparent to these kindergarten children than final likenesses, although ability of the latter type is indicated by Exercises 8, 14

TABLE 2

EXAMINER'S NOTES

Pupil	Word chosen	Note
G D B	bread	Begins with *b* and ends with *d*
G D B	bat	Starts with *b*, ends with *t*
G D B.		Repeats each word several times and studies
P C	tail	Because it's short
P C	bat	Because it's short
M G	pie	Has *p*
C G		I know by the letters
W L	paper	It's a long word
E L	drum	Spells
E L	plant	Spells
	feet	Spells
T L		Sounds letters then pronounces words
G M	feet	Spells
B M	paper	Because it's longer
R S	bat	Begins with *b*, ends with *t*
	bread	Begins with *b*, ends with *d*
	shoe	Begins with *sh*, has no *w*
	drum	Because it has *m*
	pie	Because it has *p*
	paper	Begins with *p*, ends with *r*
	wolf	Because it has an *f*
	ship	*sh* and *p*
	garden	3 *g*'s and a *t* (the exercise has the words *garden, wash, grow, gate*)
	riding	3 *r*'s (the exercise has the words *riding, hiding,* rooster, raining)
B S	drum	*d* and *m*
	paper	*p*, *p*, *r*
	bread	*b* and *d*
	rope	*r*, *p*
	gate	I don't see any *t* at end
M T	paper	2 *p*'s and *r* She sounds first and last letters

and 16 Exercise 16 is another in which a less like wrong answer, *hiding,* had a slightly larger percentage, 19, than the most like one, *riding,* which had 17 per cent, this slight difference is hardly a reliable one Each wrong word had the *ing* final ending The other two cases of higher percentages for less like wrong answers were Exercises 6 and 10. *Grass* was chosen by 19 per cent and *broom* (most like *bread*) by 12 per cent. *Doll* was chosen by 17 per cent compared with *fire* (most like feet) by 5 per cent

While giving the test to the children the examiner made note of statements made by the children or observations of how they worked to select their answers No special effort was made to elicit statements from these five-year-old children Where it seemed promising to do so, the examiner, who was an unusually experienced and competent worker with kindergarten children, asked very naively, 'How can you tell that is the word?", or the like Nearly every one of the notes indicates that letter forms or sounds were the means of approach used by the children in recognizing the words. The following notes (Table 2) were made during one test of the five-year-old kindergarten children Other similar notes were taken during other tests and with other groups, but lack of space prohibits reproducing them here.

B Reading Phonic Combinations

Sixteen phonic combinations, shown in Table 3, were used as an individual test with 47 Grade 1 pupils. The combinations were printed in large-size, lower-case letters, on a white card, one below the other in the order given in the table. The card was handed to the children, who were told that they probably did not know many of the "words," but that they were to say as many of them as they could, whether they knew them or not

In the second column of the table are shown the percentages of correct pronunciations given by the children. The third column shows the percentages of omissions, the fourth those of errors At the right are also shown, as well as the examiner could write them, the incorrect pronunciations given by the children. The last column, headed *D M* , gives the responses made by one pupil—evidently an association of words, which might be of interest to a psychiatrist! The boy was clearly neither reading nor trying to read. In fact, he has throughout the second grade been the one "reading problem"

TABLE 3

RESPONSES OF GRADE ONE PUPILS ON 16 PHONIC COMBINATION ITEMS

($N = 47$)

	Item	Number Right	Number Omitted	Number Errors	Wrong pronunciations given	D M
1	ing	25	11	11	inge(2) ange(2) ing ige ng Bingo ink inga	cat
2	er	20	10	17	en e ear are(3) or ee yar here ar(2) t-y spelled out(3)	
3.	low	20	12	15	elda like lowa look well loo owe how oal lowho elo wow t-o spelled out(1)	engine
4	es	28	7	12	ses(2) is he wise yes as eat us t-s spelled out(1)	hot
5	tr	17	12	18	her tar(2) put at tela teere kr take r-r tru teer tave tare teir(2) r-a	want
6.	sp	21	8	18	stp stop(4) up(2) pus sep(2) spil sip(2) sit sleep spelled out(2)	light
7	ch	25	10	12	clutch ca-he cod tech hurch catch ca-ha(2) some jes spelled out(1)	tops
8	ther	18	7	22	ter(2) are tech the-oo t-her they theer there(8) three the then spelled out(1)	boat
9	ver	20	10	17	visit virginia vee vere(2) very vers veir(3) var veer fine spelled out(2)	stand
10	str	17	14	16	stair estcha ester(2) stone star(2) stepper sit sister start s-t(2) sater yar spelled out(1)	
11.	ir	18	19	10	ah ear(2) ela air are Dr ar ah-va ingos	
12	ea	17	19	11	ea car yea(2) eat as spelled out(5)	
13	Sta	16	18	13	sp sit store stah stra sat(3) sita estat tha spelled out (2)	
14	su	19	13	15	soa sup is sch aou swa us(2) yus spelled out(5)	
15.	lea	17	20	10	yea line ela la(3) la loa ill spelled out(1)	
16	io	4	23	20	oh (2) o-w lo(4) ioo e ah Spelled out(8)	
					Total spelled out 33	

of the group, quite innocent, the teacher reports, of reading skills of any sort, such as letter form recognition, sounds, positions and the like

Examination of the wrong pronunciations in the table shows how generally both letter forms and letter sounds were used as cues in trying to pronounce the combinations In Exercise 1 the *ing, in* and *ng* sounds were clearly favored; in Exercise 2 the *i* and *e* or *a* sounds predominated; in Exercise 3, *l, ow* or *o* were in 13 of the 15 wrong answers; etc. There were also 33 cases in which children audibly spelled out the combinations in their endeavors to get hold of the pronunciation One pupil made a significant attempt in Exercises 2, 3, and 4. It looks as if he tried out quite desperately his entire repertoire of letters—*t-y*, *t-o* and *t-s*—but did he not demonstrate that he knew words were to be attacked by their basic letter elements?

Below (Table 4) is a set of notes taken by the examiner while

TABLE 4

Test item	Examiner's notes
io	I don't know the sound for *i*
su	Is it *n* or *u*?
ther	It's *the* without the *r*
ther	Like part of *mother*
ther	Ends like *mother*
ch	Part of Richard, my name
ir	Dr , abbreviation for doctor
ch	Chicken
ch	Part of *cheek*
ing	It isn't a word
sta	I took away the *r* from *star*

giving this test to one group, as described above in connection with the word test Every one shows basic concern with letter forms or sounds. Other sets of notes showed similar attention to letters.

C Letter Abilities

The same pupils and a group of 18 four-year-old kindergarten children, were also given individual tests on certain symbol abilities The test items and results in terms of right, omitted, wrong, and the errors made, are shown in Tables 5, 6, and 7. The tests were given carefully and in such a manner that it is probable all pupils did about as much as they could. All, including the four-year-old

TABLE 5

RESPONSES OF FOUR-YEAR-OLD KINDERGARTEN PUPILS ON A SYMBOLS TEST ($N = 18$)

Item	Number Right	Number Omitted	Number Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made) No number means 1 error
				1—Giving letter sounds
s	3	13	2	e, w
k	3	15	0	
p	2	15	1	pee
j	3	14	1	not indicated
d	0	16	2	p(2)
l	3	14	1	1 (one)
h	1	15	2	n, ha
y	0	15	3	named letter(3)
				2—Recognition of short vowel sounds heard
a	8	3	7	s(2) f(3) named letter(1) not indicated(1)
o	5	4	9	i(7) of named letter(1)
e	0	7	11	s(2) f(4) a(2) m h named letter(1)
i	0	5	13	e(10) p, ink named letter(1)
u	1	8	8	a r(2) i o f n named letter(1)
				3—Recognition of consonant sounds heard
s	8	6	4	c cat z snake
d	7	10	1	dog
r	3	13	2	o g
l	3	13	2	r o
f	4	10	4	g(2) a snake
h	1	13	4	a i n huf
w	0	11	7	y(2) o(3) i suer
x	2	10	6	s(2) g hiss c e
				4—Naming capital letters
A	14	2	2	as 12
E	13	3	0	
T	8	9	1	F
M	9	9	0	
Y	8	10	0	
C	8	10	0	
L	10	7	1	P
X	6	11	1	A
Q	4	9	5	O(3) X 2
				5—Naming small letters
s	10	6	2	m 9
c	8	8	2	a(2)
y	7	10	1	r
p	7	11	0	
u	6	11	1	n
n	3	11	4	u(3) h
b	3	13	2	p(2)
d	1	13	4	p(4)

TABLE 5 (*continued*)

Item	Number Right	Number Omitted	Number Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made) No number means 1 error
			6—Writing capital letters	
A	12	6	0	
Y	6	10	2	O (inverted)
W	7	10	1	M
P	7	11	0	
K	5	11	2	X b
X	6	11	1	K
N	6	10	2	(2) (inverted)
Q	5	12	1	(inverted)
			7—Writing small letters	
c	0	12	6	S(2) E(3) G
s	4	14	0	
r	1	14	3	R
v	4	14	0	
n	2	14	2	N (inverted)
b	2	12	4	P B(2) (reversed B)
f	0	15	3	F(2) t
j	0	14	4	(3) (reversed)
			8—Writing digits	
1	12	5	1	(inverted)
8	6	10	2	B 11111111
4	6	6	6	P d(3) E (inverted d)
0	4	13	1	B
2	4	8	6	(inverted) (3) 11 + 6
7	3	11	4	(reversed) (3) 11111
3	0	10	8	5 111 E(6)
9	5	11	2	(reversed) 111111111

children, had been tested one or more times previously, and were in no way frightened or inhibited by the testing situation.

The tables show, of course, an increasing mastery of the symbols from age to age. Most interesting, however, is the evidence of letter consciousness apparent in the errors made. In nearly every instance the error is partly right For example, the name of a letter instead of its sound; the answer *snake* for the name of the letter when the *s* sound was given; or *dog,* for the letter when *d* was sounded, a *k* written for *x, d* written for *b; E* written for *e; v* for *f; h* given as the name of *n;* all these are partly right. They indicate partial learning. Underlying is the clear fact that in almost every instance the pupils were entirely aware of the form or sound nature of the test item. The details of recognition or recall were imperfect.

TABLE 6

RESPONSES OF FIVE-YEAR-OLD KINDERGARTEN PUPILS ON A SYMBOLS TEST
($N = 45$)

Item	Number Right	Number Omitted	Number Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made). No number means 1 error
				1—Giving letter sounds
s	27	18	0	
k	23	20	2	e x
p	16	27	2	pee(2)
j	19	25	1	l
d	5	36	4	p(3) b
i	28	17	0	
h	2	33	10	ju e x u tch n ae hu ch er
y	2	34	9	n(8) 2
				2—Recognition of short vowel sounds heard
a	19	10	16	f(7) s(4) 1 f(2) c o
o	21	5	19	ar r(18)
e	0	6	39	a(10) x(6) f(9) s(9) e(2) n 1 et
i	1	6	38	e(37) i
u	0	23	22	o(7) r(7) g(2) s f(2) a(2) n
				3—Recognition of consonant sounds heard
s	40	3	2	f(2)
d	31	11	3	b(2) e
r	14	28	3	a(2) u
l	16	26	3	e o a
f	25	15	5	fae fe g b c
h	4	33	8	o(2) i(2) f a i k
w	3	20	23	o(19) y(2) r i
x	3	18	24	c(12) f ch s e(3) t g k kiss
				4—Naming capital letters
A	42	3	0	
E	37	6	2	U I
T	37	8	0	
M	37	5	3	W(3)
Y	31	11	3	i e x
C	33	10	2	G(2)
L	38	7	0	
X	27	10	8	K(4) Y(2) S A
Q	26	11	8	o(4) U(3) P
				5—Naming small letters
s	38	6	1	c
c	33	9	3	us g(2)
y	30	14	1	h
p	33	11	1	b
u	30	13	2	t q
n	15	23	7	u(2) m h(3) t
b	6	31	8	d(5) a p(2)
d	8	31	6	b(2) p(3) a

TABLE 6 (*continued*)

Item	Number Right	Number Omitted	Number Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made) No number means 1 error
				6—Writing capital letters
A	40	2	3	R(3)
Y	31	12	2	1 (reversed Y)
W	28	12	5	M(5)
P	35	9	1	(reversed P)
K	32	10	3	X Y (reversed K)
X	26	17	2	S V
N	23	14	8	M (reversed N) (6)
Q	18	23	4	(reversed Q) (2) (inverted Q) U
				7—Writing small letters
e	5	18	22	E(20) B 6
s	24	15	8	R (reversed s) (2) (reversed s) (5)
r	1	17	27	A(2) R(23) 1 (reversed R)
v	14	27	4	F E W B
n	2	23	20	N(14) M(3) (reversed N) (3)
h	4	17	24	B(23) D
f	3	24	18	F(16) L 3
j	1	23	21	J(2) (8) (reversed j) (4) O E t G i (reversed j) f
				8—Writing digits
1	36	3	6	2 (inverted 1) (5)
8	30	14	1	6
4	21	5	19	P H (inverted 4) (17)
0	16	27	2	1 10
2	16	13	16	P S(2) (inverted 2) (13)
7	17	12	16	(reversed 7) (15) (inverted 7)
3	19	9	17	(reversed 3) (17)
9	9	24	12	P(2) 6 d (reversed 9) (7) 7

Several years ago the mother of a preschool child supplied the following account of how her boy recognized the words in a reading vocabulary he had learned. Although not a thorough-going piece of "scientific research," its suggestiveness in connection with particular ways in which young children use letters, seems of special interest for this report. The mother's name, unfortunately, was not kept, and only her intelligent and painstaking anonymity can be hereby recognized.

Word Recognition by a Preschool Child as Reported by His Mother

DOG	tick on *G* suggestive of tail
I	memory
A	memory
CUP	*U* looks like cup
SAM	Father's name Letter *M* always suggests SAM

BALL	*L* suggested golf-stick, hence ball
HORSE	*H* suggested "big feet" *H* always suggests horse
BO	*Y* suggested himself with arms upraised *Y* always suggested boy
BOX	*X* remembered as a design on a box once viewed
TOY	*T* suggested a toy hammer
DAVE	favorite uncle whom he admired for "muscles" *D* represented "big muscle"
UNCLE	remembered by length of word
MARTY	favorite cousin, big word with *Y* (boy) meant Marty
LIKE	remembered by *K*, *K* always called word like
MEAT	memory
PLAY	*P* suggested racquet Spoke of tennis and golf as "racquet ball" and "golf ball"
MILK	combination of *I* and *K* always made him say "I like milk (milk favorite food)
BOAT	memory (fond of boats)
TOP	memory (newest toy at that time)
CAT	memory (*C* pronunciation taught as *K*)
BED	*B* suggested pillows
NOSE	nose suggested by resemblance of mother's nose to *S*
TALK	memory
COAT	*O* looked like a button
EYE	eye remembered as being one on each side, i e , one *E* on each end
LOOK	*OO* meant two eyes which reminded him of "to look"
NO	remembered (favorite word)
LAZARUS	his name remembered *Z* always suggested Lazarus
TEA	memory (fondness for tea)
PEN	remembered because of pleasurable privilege to use one

TABLE 7

RESPONSES OF GRADE ONE PUPILS ON A SYMBOLS TEST ($N = 47$)

Item	Number Right	Number Omitted	Number Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made) No number means 1 error
				1—Giving letter sounds
s	40	2	5	eh c named letter (3)
k	37	3	7	gay b named letter (5)
p	37	5	5	h q named letter (3)
j	38	6	3	ah ja named letter (1)
d	32	6	9	ra-h b (3) a (3) named letter (2)
i	28	5	14	ah (5) eh isa oh ahi j ugh named letter (3)
h	19	10	18	ch (5) e eh (2) a (2) in ga named letter (6)
y	13	7	27	wa (7) e ie vaya ya (4) oo on (2) yoo waha yah na med letter 5 Total named letters 28
				2—Recognition of short vowel sounds heard
a	20	4	23	si r (6) i (10) v (2) 1 (2) e (2)
o	36	4	7	o R (2) ii ou or n
e	14	3	30	a (17) s (2) t f (3) h ah v en
i	9	6	32	e (23) y i it u j c a (2)
u	6	10	31	a (11) i (5) en ou o (7) h (2) f r e

TABLE 7 (*continued*)

Item	Number Right	Number Omitted	Number Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made) No number means 1 error
		3—Recognition of consonant sounds heard		
s	44	2	1	c
d	44	3	0	
r	38	6	3	f(2) j
l	33	11	3	n e c
f	36	7	4	c v(3)
h	25	16	6	a c j l g i
w	18	11	18	y(14) o was oy c
x	25	10	12	c(3) sc c ek k(2) s z q b
		4—Naming of capital letters		
A	47	0	0	
E	45	1	1	B
T	46	1	0	
M	44	2	1	N
Y	45	2	0	
C	45	2	0	
L	46	1	0	
X	39	4	4	K(4)
Q	40	4	3	O(2) j
		5—Naming small letters		
s	47	0	0	
c	44	2	1	o
y	43	4	0	
p	43	3	1	b
u	44	2	1	w
n	43	3	1	m
b	32	4	11	d(9) p a
d	36	5	6	b(5) c
		6—Writing capital letters		
A	44	1	2	(inverted A) a
Y	43	3	1	X
W	43	1	3	H M e
P	42	2	3	D(2) c
K	41	2	4	X K R L
X	40	5	2	K A
N	36	3	8	M G, A, reversed N (4), P
Q	41	3	3	O An M O
		7—Writing small letters		
e	43	1	3	E(2) A
s	41	3	3	S (reversed s) (2)
r	38	1	8	R(4) A n (inverted T, reversed B)
v	37	8	2	D M
n	37	1	9	N(6) h (reversed h) (2)
b	35	3	9	B(4) h d P(2) R
f	34	3	10	F(4) K A (reversed f)(2) (2)/
j	20	3	24	J(8) G (reversed j) (13) f

TABLE 7 (*continued*)

Item	Right	Omitted Number	Wrong	Errors made (the numbers in parentheses show how many of the errors preceding were made) No number means 1 error.
				8—Writing digits
1	46	0	1	(inverted 1)
8	46	1	0	
4	32	0	15	(inverted h) (15)
0	4	4	1	A
2	33	1	13	6 (13) (inverted !)
7	34	1	12	
3	30	1	16	(reversed 3) (16)
9	28	1	18	(reversed 9) (16) p 2

The conclusion from the analysis of these responses is that the children studied were letter conscious in the early stages of reading progress which they were in Perhaps this fact may be explained in part by home and school training In the school experiences of the children functional attention had been given to these symbols as well as to other reading skills. If the children by nature, however, had not been "ready" to profit by the quite limited reading training provided them in the school, and probably in most homes, it seems unlikely that they would have progressed as far as they had in these skills. The evidence seems to point to early and clear attention by young children to letter forms and sounds as basic elements of and keys to reading.

The practical suggestion on the basis of this hypothesis is to give children help in mastering in a functional way the forms and sounds of letters The functional way rules out phonic and letter drills It provides materials and methods that, ideally perhaps, function when children want to read and want to use reading in child life purposes felt to be worthwhile. This report does not undertake to treat this side of the matter, its purpose having been to present evidence and suggest its significance

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CHARACTERISTICS OF YOUNG GIFTED CHILDREN*

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An early inquiry into the intellectual traits of children conducted by the English scientist, Karl Pearson, revealed that intelligent children were far more conscientious, less surly, possessed of greater athletic ability, and characterized by more robustness than dull children. Subsequent research studies have tended to verify rather than to refute this finding. New research studies with more adequate controls are needed to determine in what ways young gifted children distinguish themselves, and what significance the findings have for educational guidance.

Individual test and observation records available for the entire population of a private elementary school in Brooklyn, New York, afforded the data reported in this study. All the subjects were Jewish children living in the same part of the city where the school is located. The families represented are highly homogeneous with respect to economic and social background. The school population is a selected one with an average intelligence quotient on the Stanford-Binet Test of 115. This quotient has remained fairly stable over a 10-year period. The school is organized with a progressive program and enrolls pupils from nursery school age through the eighth grade. Each child is given a Stanford-Binet examination at the time he registers, or shortly after his admission to the school. Tests are administered by an adequately trained psychologist who makes extensive notes of behavior during and after the examination. All the test and observation records were made for the school authorities to use in adjustment and guidance work with pupils and parents.

Although no set outline was followed in observing each child, the examiner usually noted the child's cooperation, attitude, temperament, emotional stability, resistance to fatigue, concentration, interest, attention, language, vocabulary, speech habits, motor

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coordination, physical appearance, negativism and compliance, speed of response, the total impression of maturity or immaturity. The examiner also habitually recorded bits of the child's conversation, statements of his interests in school, his outside play and home activities In making the test records the examiner naturally tended to record the more outstanding traits shown by each child, whether good or bad, favorable or unfavorable, rather than the usual, ordinary, or commonplace characteristics.

All reports of examinations were written and submitted to the school within a day or so following the examination In making predictive statements about individuals or in rating their qualities, the examiner kept in mind the typical child in the school where these children were enrolled, rather than the average or normal child of 100 *IQ*. Consequently "unfavorable" qualities were unfavorable only in a relative sense, that is, unfavorable as compared with the typical child in the school of 115 *IQ*. For example, if the statement was made, "fatigues more than average," this did not mean "fatigues more than average for a typical child of 100 *IQ*" but for the typical child in the school. A notation such as "immature language" would mean, then, not immature compared with typical children, but immature compared with relatively bright children *IQ*'s were not computed until all the notes regarding a child had been recorded Consequently the examiner, in observing children, was not influenced by previous knowledge of the intelligence rating. The testing situation was kept constant for all of the children, except that younger children were sometimes shown picture books or given games to play before the actual test was begun.

Although observation of a child's behavior during a single test may be neither an adequate nor reliable sampling of his behavior as a whole, nevertheless when many such records are added together, the composite picture becomes highly reliable.

A Selection of Cases

From the available test records made at the school during a 10-year period, all cases were selected for whom there were adequate reports of children who rated over 130 *IQ*, and for whom a control case could be found of the same age and sex, with an *IQ* between 90 and 110. The number of cases thus obtained for several age levels was as follows:

TABLE 1

TCHED CASES OF GIFTED AND CONTROL CHILDREN SELECTED FOR STUDY

Sex	*CA*	*MA*	*IQ*	*CA*	*MA*	*IQ*
F	3- 8	5- 6	150	3- 9	3- 6	94
F	3-11	5- 6	140	4- 1	4- 6	110
F	4- 1	5-10	143	4- 1	4- 6	110
F	4- 4	6- 6	150	4- 4	4- 4	100
F	4- 6	5-10	130	4- 8	4-10	103
F	4-10	6- 8	138	4- 9	5- 2	108
F	4- 0	5- 8	142	4- 4	4- 4	100
F	4- 6	5-10	130	4- 8	4- 6	96
F	4- 7	6- 0	131	4- 9	4- 8	98
M	4- 1	5- 6	135	4- 3	4- 0	94
M	4- 4	6- 6	150	4- 3	4- 2	98
M	4- 7	6- 6	142	4- 7	4- 6	98
M	4- 5	6- 0	136	4- 5	4- 6	102
M	4-10	6- 4	131	4- 9	5- 2	109
M	4- 5	5-10	132	4- 6	4- 8	104
F	5- 1	6- 8	131	5- 1	5- 4	105
F	5- 7	7- 4	131	5- 7	5- 8	101
M	5- 0	6- 6	130	5- 1	5- 2	102
F	5- 6	8- 0	145	5- 7	5- 0	90
M	5-11	7-10	132	5-11	6- 0	101
M	5- 3	7- 0	133	5- 3	5- 4	102
F	5- 3	6-10	130	5- 4	5- 6	103
M	5- 7	8- 0	143	5- 8	5- 6	97
F	5-11	8- 0	135	5-11	6- 2	104
M	5- 9	8- 6	148	5- 8	5- 6	97
F	5- 1	6-10	134	5- 1	5- 6	108
M	5- 9	8- 4	145	5- 9	6- 4	110
M	5- 9	7- 8	133	5-10	5- 4	91
F	5-11	7-10	132	5-11	6- 2	104
F	5- 6	7- 2	130	5- 7	5- 2	93
M	5- 7	7- 4	131	5- 8	6- 1	107
F	5- 8	7- 4	130	5- 8	6- 2	109
F	6- 0	8- 0	133	6- 0	6- 2	103
M	6- 8	8- 8	130	6- 7	7- 0	106
M	6- 4	8- 7	136	6- 4	6-10	108
M	6- 8	8- 8	130	6-10	7- 2	105
M	6- 4	9- 9	154	6- 4	6- 6	103
M	6- 4	8- 5	133	6- 6	6- 8	103
F	6-11	9- 4	135	6- 9	7- 5	110
M	6- 2	9- 0	146	6- 2	6- 6	105
F	7- 3	10- 5	144	7- 3	7-10	108
F	7- 2	9- 6	133	7- 2	7- 2	100
M	8- 0	11-11	149	8- 0	8-10	110
M	8- 0	11- 6	144	8- 3	8- 4	101
M	8- 7	13-10	161	8- 9	8- 2	93
M	8- 1	13- 5	166	8- 4	8- 2	98
M	9- 6	14-11	157	9- 7	9- 9	102
M	9- 3	15- 7	168	9- 3	9- 5	102
M	9- 5	12- 5	132	9- 6	10- 3	107
M	9- 8	13- 1	135	9-10	10- 1	103

Ages 3-4	15 cases
5	17
6	8
7	2
8	4
9	4

In Table 1 the sex, chronological age, mental age and *IQ* of each child at the time of the test are listed.

The total number of boys was 28, girls 22 The distribution of chronological age for the two groups is given in Table 2

TABLE 2

	Gifted	Control
10-0		
9-9		1
9-6	2	2
9-3	2	1
9-0		
8-9		1
8-6	1	
8-3		2
8-0	3	1
7-9		
7-6		
7-3	1	1
7-0	1	1
6-9	1	2
6-6	2	2
6-3	3	2
6-0	2	2
5-9	6	5
5-6	6	7
5-3	2	2
5-0	3	3
4-9	2	3
4-6	4	4
4-3	4	5
4-0	3	2
3-9	1	1
3-6	1	
3-0		
Median	5 55	5 52

The distribution of *IQ*'s is given in Table 3

The difference of 33 4 points *IQ* is a statistically reliable difference which indicates that we are dealing with two significantly different groups

TABLE 3

IQ	Gifted	Control
170		
165	2	
160	1	
155	1	
150	4	
145	5	
140	7	
135	7	
130	23	
125		
120		
115		
110		5
105		12
100		20
95		7
90		6
85		
80		
Median	136.4	103

More five-year-olds are included in the selection because children were more frequently tested at that age than at any other. More boys than girls are included in the study because boys are proportionately more numerous in the school population. It was not always possible to get a control child matching the gifted exactly in age. When identical matching was impossible, a control child a month or so older than the gifted child was selected, rather than a slightly younger child, in order to give any advantage in age to the control group. Actually the median ages for the two groups are the same to the first decimal place. Records were not included of children who had not cooperated to their fullest extent or had persisted in negative behavior to such an extent as to make an adequate estimate of ability impossible.

After the cases were selected and matched, the written observation and test records were subjected to an intensive analysis.

B. Analysis of the Records

Favorable and unfavorable traits were listed uniformly for each child. A general comparison of the favorable and unfavorable traits possessed by the two groups can be obtained by counting the

number of lines of favorable and unfavorable notations for each group The tabulation is as follows

	Gifted	Control
Favorable	451 lines	95 line
Unfavorable	55 lines	250 lines

Favorable comments were recorded for the gifted group nearly five times as frequently as for the control group Unfavorable notations were nearly five times as frequent for the control group as for the gifted

1 *Summary of Traits for the Gifted and Control Groups* The following is a summary of all the traits in the two groups (Table 4). The frequency indicates the number of reports in which each trait was mentioned.

TABLE 4

Gifted children—favorable, age group 3-4 years	
Superior language, conversation, fluent speech, diction, vocabulary	14
Remarkable child all-around, capable, bright, intelligent, mature	13
Gives information, tells of interests, describes experiences	10
Well-sustained attention	9
Alert	7
Quick, prompt responses	6
At ease, at home with the test	5
Able to write name or a few words	5
Clear enunciation, good inflection	4
Cooperative, helpful	4
Comprehension superior	4
Attractive physically, good features and physique, handsome hair, eyes, or complexion, large for age	4
Serious, matter-of-fact, business-like, sensible, concentration	4
Playful, happy disposition	3
Independent	3
Mature thinking and reasoning	2
Patient	2
Mature socially	2
No fatigue	2
Full response	2
Responsive	2
Accurate	2
Energetic	2
Self-assurance	2
Interested in the test	2
Self-controlled	2
Talent with numbers	2
Sings voluntarily	1
Not easily discouraged	1
Enthusiastic	1
Good definitions	1
Imagination	1

TABLE 4 (*continued*)

Eager for knowledge	1
Ability in drawing	1
Full of life	1
Dominant speech	1
Came readily for test	1
Good quality of response	1
Not insistent on own way	1
Knows other language	1
Speaks voluntarily	1
Sense of humor	1
Interesting	1
Tells long stories	1
Insight	1
Motor control	1
Ease of accomplishment	1

Control group—favorable, ages 3-4

Cooperation	5
Conversation intelligent, expresses self well, talkative, remarks interesting	5
Imaginative, playful	3
Large for age, strong, good health	3
Happy	2
Attractive	2
Marked interest	2
Socially mature	1
Tells of family	1
Sensible	1
Came readily for test	1
Good worker	1
Responsive	1
Gives information	1
Left mother readily	1
Alert	1
Sang voluntarily	1
Serious attitude toward test	1
Easy to control	1

Gifted children—unfavorable, age group 3-4 years

Restless at the end of a long test	2
Not warm response	1
Evaded difficult problems	1
Asked for mother in difficulty	1
Showed off by rolling about after tests	1

TABLE 4 (*continued*)

Control group—unfavorable, age group 3-4 years

Stubborn, negative, shy	9	Babyish speech	1
Face lacks expression	2	Wanted to take things home	1
Limited language	3	Argues unpleasantly	1
Seldom smiles or laughs	2	Spoiled	1
Asks for mother	2	Rude	1
Poor attention and cooperation	2	Highly emotional	1
Immature conduct	2	Scowled	1
		Difficult to manage	1
Wears glasses to correct strabismus	2	Whispered answers	1
Face lacks expression	2	Stamped on floor, slammed things on table	1
Easily led	1	Not agreeable to work with	1
Lacks independence	1	Sucked fingers	1
Highly suggestible	1	Voice monotonous	1
Mind seems opaque	1	Clung to teacher	1
Comprehension poor	1	Slow adjusting to test	1
Slow	1	Annoyed at difficult items	1
Defective enunciation	1	Unfriendly	1
Limited speech	1	Gave age far wrong	1
Unresponsive	1	Poor adaptation to test	1
		Wanted own way	1
		Couldn't cooperate well	1
		Restless	1
		Difficult to manage	1
		Feminine characteristics (boy)	1
		Babyish	1
		Not strong reaction	1
		Shows fatigue on hard items	1
		Doesn't wait for directions	1
		Immature conversation	1
		Unnecessary, irrelevant comments	1

The control group proved to be perfectly normal children, on the whole, yet in comparison with the gifted group their relatively unfavorable traits stand out in sharp contrast They seem almost dull or retarded in comparison with the more capable group. The control group is, however, unquestionably typical of average children such as those on whom the test was standardized, in language equipment and responsiveness to the test.

The argument might be offered that the *IQ*'s of the control group are comparatively low because they are dependent upon personality traits which these children lack It may be argued, for instance, that the gifted score high because they converse so readily. However, only a minimum amount of conversation is needed for success

TABLE 4 (*continued*)

Gifted children—favorable traits, age 5	
Alert, bright, capable, active, eager, most outstanding	16
Conversation mature, English excellent quality, expressive, simplicity of speech, talked readily	13
Mature mentally, clever, highly intelligent, good judgment, analytical reasoning, mature comprehension, brilliant responses	7
Related experiences, descriptive powers, vivid descriptions	6
Quick, rapid responses, speed of reaction	6
Mature beyond years, people regard child as older	5
Quick comprehension or superior comprehension	5
Superior reasoning, holds problem in mind well, clear thinking, high quality of response	5
Superior drawing ability, likes drawing and painting, artistic aptitude	5
Attention well sustained, even in more difficult items	5
Playful, happy, likeable	4
Wrote name	4
Well-informed, superior information and knowledge	4
Business-like, systematic, short-cut in problem solving	4
Interested in test	3
Mature physique, beautiful physique, excellent health, large, well, and strong	3
Enjoyed test, eager for test	3
Superior control	3
Quick response	3
Good effort	2
Sense of humor	2
Obedient	2
Attractive appearance, eyes, hair, pretty child	2
Concentration	2
Imagination, creative ability	2
Accurate	2
Read number on score sheet, wrote or read numbers	2
Self-confident, knows everything	2
Easily stimulated to highest achievement	2
Interested in dress	1
Well adjusted	1
Could read a little	1
Interested in drawing	1
Charming expression	1
Steady worker	1
Sure of self	1
Proud of achievement	1
Tried hard things	1
Remarkable insight	1
Quick, direct attack on problems	1
Superior definitions	1
Clear, direct response	1
Loud, clear voice	1
Patient and painstaking	1
Logical	1
Knows exactly what he wants to do	1
Stayed till activities were completed	1
Reads	1
Exact	1
Unusual in every way	1
Took aptitude for granted	1
Eager for mental and intellectual tasks	1
Ideas original, expressions astonishing	1
Sensible	1
Knows other languages	1
Demonstrates skill on piano	1
Loves music	1
Adds coins	1
Twelve-year picture interpretation	1
Recites and sings	1
Memory unusual	1
Helpful, cooperative, responsive	1

TABLE 4 (*continued*)

Control group—favorable traits, age 5			
Conversed readily	4	Worked intently	1
Came readily for test	2	Recited verses	1
Cooperated well	2	Relates experiences in detail	1
Restless	2	Sensible	1
Good English and language usage	2	Attempted everything	1
Well adjusted	2		
Fine looking, well developed for age, tall for age	2		
Gave impression of maturity	1		
Good coordination	1		
Enjoyed test	1		
Large for age	1		
Special ability in numbers	1		
Responded promptly	1		
Alive and alert	1		
Interested	1		
Gifted children—unfavorable traits, age 5			
Restless	2		
Overdependence on mother	1		
Attention not well sustained	1		
Distracted by things in room	1		
Indistinct, immature enunciation	1		
Nervous tension	1		
Weak and incorrect articulation of initial and final sounds	1		
Willful	1		

on the test, especially at the lower levels. As a group the bright went far beyond the requirements that the test makes of the subject in order to earn credit on the test

2. *Additional Data from the Test Reports.* There was evidence, either in the children's comments or speech accent, that a number of the group knew other languages than English The records show that seven of the gifted group and three of the control group had had considerable experience with a foreign language. The languages these children had learned, in some cases preceding the use of English, included Hebrew, Yiddish, German, French, and Russian. It is sometimes argued that children are at a disadvantage in taking verbal tests when they have a foreign language background The test records show little evidence of this fact On the contrary,

TABLE 4 (*continued*)

Control group—unfavorable traits, age 5			
Immature reasoning ability	3	Argued and tended to bargain	1
Negative attitude	3	Wanted mother	1
Immature speech, speech slow and labored	3	Flat refusal to comply at times	1
Apprehensive of difficult tests	2	Lacks vivacity	1
Immature behavior	2	Heavy personality	1
Came shyly or acted shy	2	Sucks thumb	1
Uncouth, not well groomed	1	Wiggles and jerks	1
Lacks self-control	1	Difficulty in comprehension	1
Unfavorable behavior	1	Wanted examiner to read as substitute for the test	1
Disinclined to play, needs restraining	1	A bit stubborn	1
Decided accent, restricted speech	1	Talked little except about self	1
Inflexible	1	Interrupted work to play with blocks	1
Interest never at high pitch	1	Poor concentration	1
Concerned at not finding other children in the room	1	Not sensitive to errors	1
Hard to control	1	Conversation lacks content	1
Did not take seat indicated	1	Immature drawing	1
Asked for mother	1	Name writing too difficult	1
Did not know birthdate	1	Slow response	1
Could not comprehend directions	1	Repressed	1
Inability to follow directions	1	Unpleasant to work with	1
Play was infantile	1	Waits for help on problems	1
Immature reaction to picture book	1	Little effort	1
Lacks information	1	Often says "I don't know"	1
Says does not know hard things	1	Responses of inferior quality	1
		Responded only to examiner's questions	1
		Small for age	1

knowledge of another language in the case of the bright seemed only to have enriched meaning and to have enlarged the child's knowledge

The negativism exhibited was of two sorts: first, initial shyness due to fear of the strange situation shown more frequently by the younger children This initial shyness usually wore off quickly as the children became acquainted with the examiner and familiar with the situation The second type of negativism was shown as the test became increasingly difficult and the child tended to turn away from an unpleasant task This type of negativism was shown

TABLE 4 (*continued*)

Gifted children—favorable traits, ages 6 and 7			
Bright, unusually competent, very capable, mature mentally	9	Bored with easy tests	1
Business-like, no lost motion	4	Direct replies	2
Quick reactions	4	Large for age	2
General information	4	Seems several years older	1
Alert, keen perception	4	Enthusiastic	1
Speech and conversation of superior quality	6	Dramatic feeling	1
Direct replies	2	Poetical expression	1
Large for age	2	Attractive personality	1
Humorous	2	Well-controlled	1
Knows languages	2	Excellent attention	1
No conceit	2	Very expressive	1
Arithmetic	2	Hopes to become a judge	1
Superior reasoning	3	Artistic ability	1
Superior comprehension	3	Expressive eyes	1
Reading	2		
Enjoys test	1		
Responsive	1		
Sensible	1		
Enjoys books at home	1		
Meets situations well	1		
Good judgment	1		
Wants to be a gentleman	1		
Control group—favorable traits, ages 6 and 7			
Coöperative, responsive	2		
Likes to read	2		
Large for age	1		
Easy to control	1		
Volunteers information	1		
Cheerful, pleasant, easy to work with	1		
Energetic	1		
Direct replies	1		
Eager for tests	1		
Frank	1		
Good effort	1		
Attention	1		
Prides self on achievement	1		

more frequently by the control group. Negativism is, of course, not an unfavorable sign in the case of young, normal children at the three- and four-year-old levels. According to developmental research studies, negativism reaches its maximum in this age range, and then ordinarily disappears. Hence, in our records for this age

TABLE 4 (*continued*)

Gifted children—unfavorable traits, ages 6 and 7	
Shy	1
Baby talk	1
Slow drawl	1
Thin, ill-nourished	1
Tense, emotional	1
Babyish	1
Small for age	1
Effeminate traits (boy)	1
Manners stilted, stereotyped	1
Says cannot do it, never had the test	1
Makes excuses, evades responsibilities	1
Speech not clear	1
Not playful nor happy	1
Wears glasses	1

Control group—unfavorable traits, ages 6 and 7	
Quiet	2
Asked for test items to be repeated	2
Slow in speaking	1
Wears glasses to correct strabismus or other defect	3
Not expressive	1
Listless	1
Doesn't exert self	1
Shows fatigue	1
Nasal speech	1
Could not comprehend questions	1
Annoyed at examiner	1
Shy	1
Reluctant to respond	1
Talks little	1
Pale	1
Weak voiced	1
Declined at first to come	1
Interrupted frequently	1
Did not await directions	1
Hard to control	1
Says "I don't know" or "I can't"	1
Restless	1
Asks silly, trivial, questions unrelated to the test	1
Speech indistinct	1
Slow comprehension	1
Slow in figuring out problems	1
Immature writing	1
Eyes weak, lids red	1

TABLE 4 (*continued*)

Gifted children—favorable traits, ages 8 and 9			
Mature mentally, mature judgments and ideas	5	Languages	2
Superior reading ability	5	Precise	1
Quick, rapid responses	5	Efficient, well-organized	1
Superior speech and vocabulary	4	Carries out directions	1
Well-mannered, pleasant disposition	4	Relates incidents	1
Superior in arithmetic and mathematical ability	4	Responsive	1
Self-control	4	Superior thinking	1
Quick comprehension, or superior comprehension	3	Alert	1
Reasons well	2	Exact	1
Mature in manner	2	Good health	1
Physically mature	2	Wants to be a doctor	1
Language mature	2	History and geography knowledge	1
Nice-looking, handsome	2	Dramatic expression	1
		Self-assured	1
		Likes school	1
		Works efficiently	1
		Works conscientiously	1
		Honest with self	1
		Difficulties stimulate more effort	1
		Works hard problems easily	1
		Plays piano	1

Control group—favorable traits, ages 8 and 9			
Good vocabulary	2	Cooperates well	1
Direct replies	2	Concentrates well	1
Pleasant	1	Quick	1
Responded freely	1	Good habits of work	1
Sense of humor	1	Gave information	1
Reading	1		
Neat and painstaking	1		
Nice looking	1		

level we would expect to find, as we do, a normal amount of resistive tendency But the absence of this tendency is noteworthy, for the most part, in the gifted group three and four years old The slower children, more than the bright, seemed to require a "warming-up" period

An outstanding trait of the young gifted child, judged from the results of this study, is the capacity to persevere in the face of difficulty The gifted child sustains his attention to problems and maintains interest in them even when he recognizes that they contain difficulties insurmountable for him He remains happy in this

TABLE 4 (*continued*)

Control group—unfavorable traits, ages 8 and 9			
Immature emotionally	1	Awkward expression, accent	1
Exhibition of nervousness	1	Little patience in problems	1
Self-conscious	1	Wears glasses	1
Repressed	1		
Suspicious	1		
Monotonous voice	1		
Special help in reading	2		
Immature	2		
Slow, confused thinking	2		
Slow response in vocabulary	1		
Severe stutter	1		
Timid, hesitant, little self-assurance	1		
Difficulty in conversation	1		
Vocabulary limited	1		
Asked for test to be repeated	1		
Slow in responding	1		
Poor in arithmetic	1		
Poor reasoning	1		
Restless	1		
Hands show tremor	1		
Pulls hair, bites nails	1		
Sucks fingers	1		
Strabismus	1		
Faulty articulation	1		
Childishly immature	1		
Apprehensive of test	1		
Not expressive	1		
Not well-informed	1		
Not fluent language	1		
Word usage limited	1		
Fatigues easily	1		

situation, not sullen nor recalcitrant He keeps himself busy by setting tasks for himself, seems to have an inexhaustible supply of mental energy to expend, maintains a pleasant attitude when difficulties arise, tends to laugh or joke or say, "Well, that's one on me," or he is frank to say, "I guess I can't get that one" The gifted child seldom offers alibis and does not tend to project his failures beyond himself His mental energy is comparable with an electric filament that glows continuously without exhausting itself He hungers for problems, asks for more or invents new problems when the supply gives out

The brighter children included in this study seemed to enjoy a challenging task They delighted in attempting problems too diffi-

cult for them to solve. On the contrary, the slower child seemed even to dislike doing what he proved well able to do. The brighter group tended to hold the problems in mind better than the control group The bright children were also more willing than the control group to defer their personal desires until the test was completed They could hold personal wishes in abeyance and do the disagreeable tasks and see the reasonableness of doing the disagreeable tasks first It was easier to enlist the interest, to call forth the best effort of the more gifted children. Outstanding traits of the gifted child proved to be superior speed of work, quick responsiveness, and quick comprehension The gifted children did not so frequently interrupt their work in the midst of an activity to suggest other activities by requests to leave the room or terminate the test

At the five-year level, these gifted traits seemed to show up more distinctly than at the other age levels represented in the cases described here It may be that from this point on the leveling effects of schooling tends to prevent children from exhibiting their more typical personality traits, even though they still rate high on mental tests

Quite apart from the test scores themselves, the gifted children at age five tended to show a combination of the following traits in many individual cases. high mental energy, low fatigue threshold, alertness, speed of response, mature speech and language. They exhibited in general playful, gay, humorous attitudes, well-sustained attention, ability to follow directions well, to become absorbed in a task, to maintain a businesslike attitude. They were, on the whole, good-looking children with good physique. They enjoyed many activities and could describe them accurately. Most of these young gifted children showed little fatigue even at the end of a comparatively long test period It was often necessary to continue the test through the 10-year level with these five-year-olds, yet attention and interest were maintained on a high level.

There seems to be some evidence from repeated test data that the children who rate 130 *IQ* at age 3, 4, or 5, are actually more gifted than children rating 130 *IQ* at age 8 or 9 because the intelligence quotients of gifted children tend to rise with age. Consequently it may be that the younger group represented in this study are actually more highly selected than the older group, a fact

that may account for the somewhat greater difference found in comparing the gifted group with the control group at the two levels Many of these older gifted children had attended formal public schools, and this fact, too, must be considered in evaluating their reports.

3. *Selected Reports of Gifted Children* The following verbatim excerpts from the test reports for eight children will illustrate the types of records kept and illustrate typical children in the gifted group

CHILD No 1

CA, 3-8, *MA*, 5-6, *IQ*, 150

S is a remarkable child in all respects She is large for her age, most mature in thought and action Everything she attempted was done with the greatest ease Her enunciation was very clear, her cooperation excellent, her motor control unusual for a child of this age She maintained superior attention to the end of the test, comprehending each problem clearly and replying promptly When she was confronted with a question which she could not answer, she promptly said that she did not know Even in the more difficult tests of the eight-year level she was very patient, and never discouraged All of the time she was enthusiastic about the things she was doing *S* has no brothers or sisters, but she is very well developed socially She has attended another kindergarten where she says the thing she liked to do best was playing with clay

CHILD No 4

CA, 4-4; *MA*, 6-6, *IQ*, 150

S was most unusual in his ability to express ideas fluently and completely Yet during the entire test he maintained excellent self-control considering his age Some of his remarks were astonishing in a child so young He was well oriented with respect to his age and other facts of general information, and exceptional in his ability to comprehend test questions beyond his age level As the test progressed he continued talking in his fluent, lucid, and direct way, giving me a large stock of information about himself He proved to be as alert a child as I have seen in some time Once he commented, "I come to school very joyously," but hastened to add that this comment was written by his teacher on a note to his mother He apparently understood the import of this comment and prides himself on his satisfactory behavior He joked with me about

several of the tests, using as he talked a voice with a charming inflection

S was a most observant child He commented that the tests he was having were not games, but on the contrary "important things." He was alert in playing a game with the crayons, while he hid his eyes, and then was asked to guess which one was missing He told a number of long stories, apparently true ones, relating to his summer camp experiences. When I stopped the test at the nine-year level, *S* had not yet given any signs of restlessness, but had worked steadily for well over half an hour, without protest, and with remarkable concentration

The child has already shown some interest in writing his name He was able to write two letters of his name, and indicated the rest as two separate words, with scribbles to represent both his first and last name

Child No 7

CA, 4-0, *MA*, 5-8, *IQ*, 142

A more attractive child than *S* would be difficult to find, for she is as cheerful, happy and gay as she is intelligent, and in addition has good features and physique Her speech is quite clear for this age and her ability to express herself considerably above the average Her answers were given so glibly that my first impression was that she must have been coached, but this proved not to be true When she was asked where she had learned all of these things she said, "No one told me I knew since I was a baby" At the mention of baby she described vividly a baby in her neighborhood *S* has an unusual amount of information for a child of this age, and most of it seems to have been acquired as a result of the child's own interest and curiosity She was able to follow all instructions in connection with the test very well Toward the end of the test she became restless as any child of this age would, but her attention throughout was well-sustained

Child No 23

CA, 5-7, *MA*, 8-0, *IQ*, 143

S came for the test with an eager, alert, expectant air From the outset he proved to be remarkable in the insight he showed into the different test situations, in his ability to comprehend difficult problems, and in the imagination he used in working with the materials He maintained his initial eager

alertness throughout the entire test period, seeming in this respect more like a seven- or eight-year-old than a child not yet six His thinking was invariably clear, and his attack on any problem quick as well as direct To test *S* adequately it was necessary to continue through the 10-year level of the test Even though all of these items were failed from the standpoint of 10-year standards, many of his partial successes rated at a high level, and the quality of his responses was invariably superior He comprehended the problem of arranging blocks of different weight without the slightest difficulty and then commented that the blocks must have something inside of them When I inquired "What?" he said, "Lead" But added, pointing to the three-gram weight, "That hasn't anything in it," an observation that was quite true *S* was businesslike in his approach to each problem, and although he was never verbose, his verbal responses were neatly phrased, characterized by simplicity He showed superior motor control in his attempt to copy a diamond On the Animal Puzzle he made a perfect score in less than four minutes, a remarkable achievement for a child of this age. In other picture tests he showed superior vocabulary and diction, "They're Pilgrims," "It's a cat—a Cheshire cat" *S* caught sight of some numbers and proceeded to read them very glibly When I inquired where he had learned them, he said his mother had taught him to write He himself was able to write the numbers from one to ten, but in making the number ten he commented, "I'll just make the 'O' part, because you see up here I've already written the one"

CHILD No 27

CA, 5-9, *MA*, 8-4, *IQ*, 145

S is an unusual child in every respect He seems to recognize this himself for he made frequent remarks about his mental ability, readiness in learning, and successful accomplishments He seems to take his aptitudes for granted and seems to think it entirely natural for him to be "so smart" His outstanding traits are mature comprehension, speed of reaction, sense of humor, eagerness for mental or intellectual tasks He expresses his thoughts in most original and sometimes astonishing ways For example, he volunteered to tell about the impression that music makes on him, " like horses dashing up the mountainside When they go faster the music is louder" He says that he sees all of this inside of him He remarked

that sometimes he feels lonesome and that when he does he draws pictures or plays with his toys All of his responses were given systematically and the boy took short-cuts in solving problems whenever he saw the opportunity He quickly identified the coins and then added up their total value His picture interpretation just missed a rating on the 12-year level He is keenly analytical. A little nervousness was evident in the child's eagerness to accomplish the different tasks, but this is not to be interpreted as instability The child was frankly bored by the easier tests but he restrained his impatience admirably His attention was remarkably well-sustained

Child No. 37

CA, 6-4, *MA*, 9-9, *IQ*, 154

S is an unusual boy in all respects Since he is large for his age, he is readily mistaken for a child several years older His muscular coordinations show almost none of the immaturity which characterizes the average child of six On the surface he appears to have a somewhat lazy and indifferent, careless attitude, but he is actually the opposite when it comes to mental functioning At times he became quite excited and enthusiastic, gesticulating, waving both hands, and showing much dramatic feeling At other times he appeared bored with the examination but able to tolerate it

His responses throughout were of superior quality and even his errors may be characterized as sensible, never wild or far from correct He gave very direct replies, frequently in a droll and dryly humorous fashion which kept the examiner laughing. The third picture of the picture interpretation series he explained as, "One old Jew with the paper All the other Jews around are too stingy to buy their own and are trying to look on," a clever and yet sensible interpretation His use of English is not as advanced as his mental ability in general This is no doubt due to the fact that he speaks Hebrew much of the time and has used it more than English He gave superb definitions of a series of words, equal in quality in many cases to those of adults.

This child was, at the time the test was given, easily the outstanding child in the school. He was observed by the examiner five years after the test during a noon period at the school He had in hand a book of Hebrew legends that he was studying for the Hebrew high school classes he was attending daily after school At that time he was in the eighth grade

and eleven and a half years of age. He was questioned in regard to his reading and reported that in most of his reading he utilized his father's books at home. The boy had apparently isolated himself during the noon recreation period in order to read. He was looking forward expectantly to entering the ninth grade in a Brooklyn high school the next fall.

CHILD No. 41

CA, 7-3, *MA*, 10-5, *IQ*, 144

Superior mental maturity and reasoning ability characterized *S*'s responses from the beginning to the end of the test period. Yet the child is extremely modest about her accomplishments. Although I asked several questions about her success in school and her achievement compared with other children, she refused to claim any superiority for herself. *S* was quick in responding and concise in phraseology. Her vocabulary rates at the 10-year level. She formulates her answers well and shows in her informal comments a wealth of information. *S* was rather matter-of-fact in her attitude, thoroughly business-like, yet appreciative of humorous turns in the test situation. However, any emotional responses in her case were expressed with great subtlety. *S* shows extreme awareness of conditions and situations in her environment. She should certainly be characterized as a "knowing" child. It must be very difficult to fool or "catch" her in any situations where thinking and reasoning are involved.

S gave considerable information about her home, her parents, her sister, and her school experiences. She recalls that she was in first grade only three weeks, and then was put in second; now she is in third grade. Her mother teaches a 5*A* class in public school, "They have such easy work, I could do them all myself." *S* modestly admitted that she gets along well in third grade. "Arithmetic?" "It's all right." She enjoys reading, and her favorite outdoor sport is horseback riding. It seems that she rides in the park every Saturday. She also takes tap dancing and studies piano. *S* speaks with a slight speech accent, suggesting a knowledge of foreign languages, and she relates that she can speak Jewish, Hebrew, and a few words of French. *S* seems to know all about her grandparents' business activities. She also mentioned that there are three doctors in the family. When she is grown she expects to be an artist, for drawing is one of her favorite activities. She seemed pleased with a design that she had

worked out yesterday at school. *S* is a child of medium size, with a rather broad face and expressive eyes.

CHILD No. 43

CA, 8-0, *MA*, 11-11, *IQ* 149

S appeared to be somewhat perturbed when the examination was begun. He was wary of the examiner and asked a great many questions about the whys and wherefores of the examination. Eventually, however, he overcame his uneasiness and became greatly interested in the examination with much success. He reports that he likes this school better than the one he attended last year. He says he is "crazy about reading." Last night he took a book home and read it from three o'clock till almost five. He says his parents are very glad to see him so interested in reading.

The boy is precise, well-mannered, has a mature attitude, is efficient, well-organized from the standpoint of ability to deal with thought problems. He carries out directions carefully and in this respect should be the teacher's delight. Some of the tests suggested incidents to him which he related in good fashion. *S* showed special ability in dealing with problems involving number concepts. At lunch, *S* shows marked dislike of some of the food. He is most exceptional in refusing to eat his dessert. He is decidedly immature emotionally, a condition which can only be overcome through securing the parents' wholehearted cooperation.

CHILD No. 50

CA, 9-8, *MA*, 13-1, *IQ*, 135

Although *S* speaks with a slight accent, his comprehension of the test questions was so entirely adequate that I should judge little allowance need be made in the present test report for the factor of foreign language background. Some of his responses were expressed a little awkwardly, but indicate on the whole superior mental ability and mature ideas and judgment. *S* exercises excellent self-control. He knows how to work efficiently, he undertakes a task promptly and he works conscientiously until he is satisfied with the result. He is honest with himself, admitting promptly that he cannot solve a problem that is clearly beyond his comprehension level, instead of bluffing or giving a partially correct response. Difficulties cause him no emotional upsets, but only stimulate him to make more effort of an intelligent sort. In his case the good traits

are highly correlated. His ability to work a difficult problem with apparently little mental effort was shown in his success with the code test of year sixteen I showed him the code diagram for this test, but gained the impression from the casual way in which he looked at it that the problem was considerably beyond his ability level. *S*, however, succeeded in using the code correctly and earned credit for the test Throughout the test his responses to problems involving mathematical reasoning were, if anything, superior to other abilities. *S* named reading as his favorite activity He enjoys most reading history, particularly that of Medieval times, or, as he says, if he is unable to obtain a good book from the library he may read a book of fairy tales For a while he says he read all the time, a book a day, and he still continues to read a great many books within several months Piano playing is another activity he enjoys, and arithmetic he names as his favorite school subject He gave a brief account of his earlier school experiences At the age of four he attended a public school kindergarten, but he remarked that that "didn't count" At five he entered first grade, and since that time has been "skipped" twice

C Summary and Conclusions

1. Test and observation records for 50 Jewish children ranging in age from 3 to 9, and rating over 130 *IQ* on the Stanford-Binet Test, were matched for age and sex with 50 control cases of the same race and from the same school population ranging in *IQ* from 90-110

2 An analysis of the records indicates for the group as a whole nearly five times as many favorable notations of intellectual, personality and character traits for the gifted as for the controls. Conversely, comparatively unfavorable traits were noted nearly five times as frequently for the controls as for the gifted subjects.

3. The gifted group were superior to the control group in energy, physique, language, information, judgment and reasoning, sense of humor, willingness to face difficulties. They fatigued less quickly than the control group, had more experiences to relate, showed more skill and proficiency in the arts, were more active and vivacious, more independent and self-assured

More of the gifted than the control group knew and used a foreign language in addition to English

4. All these distinguishing traits were most obvious at the five-year level.

5. These results have practical diagnostic significance for child guidance specialists, teachers and parents. A tentative hypothesis may be suggested: The gifted child can be identified on the basis of certain behavior signs and trends, as well as through outcomes from standardized tests.

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THE RELIABILITY OF SUMMARIES OF RATING SCALE EVALUATIONS OF STUDENT PERSONALITY TRAITS*

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A problem common to every institution of higher learning is the evaluation of the qualifications of its students and graduates for the business and professional positions for which they are preparing. Much of the information needed for such evaluation is of course available Estimates of the individual's general intellectual ability, of his degree of proficiency in the field of his specialization and a summary of his training or experience are invariably wanted and for the most part readily obtainable But how about that highly important aspect of the individual's qualifications, the social behavior described in such terms as personal attractiveness, dependability, enthusiasm? Most of the report forms devised by bureaus of recommendation, admissions offices and personnel departments devote a considerable amount of space to inquiries concerning such matters of personality and character. To be sure, the long lists of "traits" blandly disregard the available evidence that there is no psychological uniqueness to these arbitrary entities, and the terminology is as varied as the number of report forms Moreover, many of the items listed concern such activities as cannot be observed in the college situation.

Despite these limitations, common sense experience continues to place much stress on whatever judgment can be obtained concerning how well the individual will fit into the social environment of his new position It seems reasonable to suppose that an attempt at prediction should be made, that those who are particularly well liked will in most cases continue to exhibit such facility of social adjustment, and that those who have been noticeably undependable, lacking in vigor, or prone to make themselves unpopular by lack of tact, unpleasant disposition, or over-bearing attitude, are the poorest

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prospects if their new situation requires much contact with people.

A common procedure for securing the needed information is to assemble letters, sometimes confidential and sometimes made open to inspection to the person concerned, which may be studied by a prospective employer Such problems as the uniformly over-complimentary evaluation which results from general comments, the lack of comparability of points mentioned by the various persons making the reports, and the lack of any norm with which to compare the status of the individual under consideration are neatly dodged by passing on the collection of letters to the prospective employer, who is in a still less favorable position to make the correct interpretations.

This report concerns a five-year study (1933-38) of the evaluation of personal characteristics of students by members of a university faculty It was hoped that by progressively improved procedures, some of the difficulties mentioned above might be to some extent minimized Recent analyses of results appear to be highly promising

The study began with an attempt to secure meaningful data concerning nearly a thousand undergraduates preparing to become teachers in secondary schools It was clear from the start that the class size or the nature of the procedures in certain classes make it peculiarly difficult for the instructor to become reasonably well acquainted with his students, so no requests for information were addressed to faculty members in such cases The opinion was held by several faculty members that experience in this particular institution had clearly established a preference for reports in the form of free compositions on blank sheets of paper, rather than on any type of questionnaire or rating scale. Unusual as this seemed, in view of the greater amount of work involved in attempting to write paragraphs of comments particularly as regards the large number of average students about whom nothing distinctive could be said, this question of preference was nevertheless investigated in the following manner The first report forms sent out were, when unfolded, blank sheets of paper except for the student's name and course, already typed in at the top of the page, and a line at the bottom for the instructor's signature. On the back of this blank was a very simple form of rating scale covering those items usually mentioned in letters of recommendation A tabulation of the returned reports showed that over 95 per cent had been turned over and filled out on the rating scale side This preference for the

rating scale led to the gradual modification of the form toward a scale with as many characteristics known from experimental studies to enhance reliability as seemed practical in the light of its regular use on such a large scale by such a large group of faculty members For example, the number of scale steps was increased from three to five to seven, the items were headed with a brief question instead of with a one word label naming a "trait," the questions were preceded by a sentence of instructions giving in effect a definition of the item, etc It was not considered possible to go far in the direction of splitting up general categories to emphasize highly specific items of behavior for two reasons A scale which lists many such specific reactions becomes prohibitively long and invites resentment and careless reporting Moreover, in such a practical situation closely similar aspects of behavior are not observed by all raters as would be the case in an experimental set-up, so a more general impression, of inherently less reliability but more closely parallel to observations which could be made later when the individual is employed, would be the only kind of information which could reasonably be expected from faculty reports The scale in use at the present time is reproduced in Figure 1

An important additional modification in procedure was introduced after the faculty had become familiar with the purpose of the reports and the form of the rating scale As early each term as accessibility of the records permits, a letter to each instructor indicates that a report is to be requested at the end of the term concerning the students whose names are appended. The increased likelihood of adequate observation after this information is supplied has increased the number of returned forms to nearly one hundred per cent

This regular request for ratings on a student during the four years of his college career results in a collection of 10 to 15 or more reports, filed in chronological order The most characteristic thing about the reports, as might be expected, is their lack of complete agreement Moreover, useful comments are often added in the space provided for the purpose Now the real purpose for which all this information is to be used is a final rating, on the basis of all the ratings and comments available, to enable a prospective employer to determine how favorably to regard an applicant on the basis of his personal traits The question arises whether the central tendency of the reports can be reliably determined by summarizing

OFFICE OF ADVISER TO PRE-TEACHING STUDENTS
ROOM 306 MAIN BUILDING

The information requested on this blank will be treated confidentially. It is important for advisory services to pre-teaching students, and in supplying information to schools regarding qualifications of our graduates, that this report be as accurate as possible. Please place a check mark (✓) above the phrase which best describes your judgment concerning the five items below.

ESTIMATE OF PROSPECTIVE TEACHERS

1. Consider how this student has impressed you with respect to refinement, appearance, poise, tact, general disposition. How does this student compare with others as to personal attractiveness?

Basis For Judgment

Very Unfavorable	Unfavorable Impression	Probably Below Average	About Average	Probably Above Average	Favorable Impression	Unusually Favorable

____ adequate
____ inadequate

2. Consider to what extent this student has been conscientious, prompt, honest. How does this student compare with others as to reliability?

Very Unfavorable	Unfavorable Impression	Probably Below Average	About Average	Probably Above Average	Favorable Impression	Unusually Favorable

____ adequate
____ inadequate

3. Consider this student's attitude towards others. Is it likely to be a handicap due to conceit and over-aggressiveness, or to undue timidity and lack of confidence? How has this student impressed you in regard to his self-confidence? If your opinion is unfavorable, check one of these terms:

_____ aggressive
_____ timid

Very Unfavorable	Unfavorable Impression	Probably Below Average	About Average	Probably Above Average	Favorable Impression	Unusually Favorable

____ Adequate
____ Inadequate

4. Consider the extent to which this student has impressed you as enthusiastic, forceful, dynamic. How does this student compare with others with respect to alertness?

Very Unfavorable	Unfavorable Impression	Probably Below Average	About Average	Probably Above Average	Favorable Impression	Unusually Favorable

____ adequate
____ inadequate

5. Consider this student as a prospective teacher. On the basis of your observation, to what extent would this student's personality (not scholarship) qualify him (her) for the teaching profession?

Very Unfavorable	Unfavorable Impression	Probably Below Average	About Average	Probably Above Average	Favorable Impression	Unusually Favorable

____ adequate
____ inadequate

COMMENTS

Date________________ Signature__________________

FIGURE 1

RATING SCALE FOR FACULTY USE

such a group of rating scales, or whether the final rating depends largely on the person who does the summarizing

This matter was investigated as follows The reports on file for 548 students were read and summarized independently by two persons, both familiar with the rating scale and the purpose of the reports *Each student was assigned a final rating on a nine-point* scale by both readers A scatter diagram of these summaries is given in Figure 2 The extent of agreement in terms of the coeffi-

	B1	B2	B3	B4	B5	B6	B7	B8	B9	
A9								1	11	12
A8							2	2	5	9
A7						15	71	9		95
A6				1	3	54	40	2		100
A5				2	256	11	3			272
A4			1	19	10	1				31
A3			24	3	1					28
A2										
A1	1									1
	1		25	25	270	81	116	14	16	548

FIGURE 2

A Comparison of Independent Summaries by Two Readers of Personality Ratings of a Group of Pre-Professional Students

cient of contingency is .87 (with a maximum 943 for a nine-fold table) Careful inspection of the distribution of the summaries and an interpretation of their significance in terms of the reliability of judgments concerning the persons rated indicates the following facts The large majority of cases were placed on exactly the same step by both raters Only two per cent were as much as two steps apart, which is a difference of one quintile, and in no case was there

greater disagreement than this. It would seem reasonable to conclude that this indicates satisfactory reliability of interpretation of these ratings.

In view of the high degree of objectivity which evidently attaches to summaries of these reports, it was considered worth while to study the validity of the reports in terms of their internal consistency. Presumably a student receiving a favorable rating from one group of instructors would be unlikely to receive a closely similar rating from another group unless a common causal factor lay behind the reports Inadequate acquaintance, personal prejudice, and other factors tending to unreliability of reports would obviously tend to produce disparities between reports obtained from one group of raters as compared with another On the other hand, the extent to which characteristics of behavior are accurately reported would be reflected in the degree of agreement between different sets of

	B1	B2	B3	B4	B5	B6	B7	B8	B9	
A9										
A8							2			2
A7						5	4	3	1	13
A6					7	9	5			22
A5		1	1	6	32	14	4			57
A4		1		2	1					4
A3		1			1					2
A2										
A1										
		3	1	8	41	28	15	3	1	100

FIGURE 3

RATINGS OF A GROUP OF PRE-PROFESSIONAL STUDENTS OBTAINED AFTER DIVISION INTO ALTERNATE HALVES OF THE ORIGINAL GROUP OF SCALES FOR EACH INDIVIDUAL

reports concerning the same individual. The consistency of the reports was studied in the following manner

One hundred cases were selected for each of which at least 10 ratings were on file The report forms in these 100 dockets were separated into two equal groups, choosing alternate reports for each group This sorting was done by a person who did not participate in the later phase of the study Each of the two sets of reports for the 100 students covered about the same length of time and a similar distribution of instructors. One set of reports was read and summarized on a nine-point scale by one rater, while a second made a similar summary of the other set of reports. Again the degree of agreement between these two independent evaluations is indicated by a scatter diagram (see Figure 3) The degree of relationship as measured by the coefficient of contingency is 68. If it be considered that the degree of agreement is lowered because only half of the available reports were used in each of the two summaries, and that a summary based on the entire set of rating scales might be more closely related approximately to the extent predicted by the Spearman-Brown formula, the anticipated degree of relationship would be indicated by a coefficient of 81 Interpreted in terms of significance for individual letter of recommendation, the following facts are of importance. About 50 per cent of the summaries were given the same rating Over 90 per cent of them differed by only one-ninth of the scale, which in terms of the kind of report which would be made for recommendation purposes means close similarity In no single case did one set of reports lead to a favorable, and the other set to an unfavorable rating The few cases of disagreement by two-ninths of the scale and the one case by three-ninths were found, upon re-reading of the reports, to be clearly due to the chance sorting into one group of a markedly more favorable, or less favorable, set of reports This means that if the entire ten or a dozen reports had been used as the basis for a report (as they ordinarily are) these few discrepancies would have disappeared.

Summary

A procedure has been developed for securing faculty reports concerning the probable fitness for the teaching profession of undergraduate students in a pre-teaching curriculum, insofar as traits of

personality and character are concerned Analysis of the objectivity of summaries of these reports indicates that they are affected to a negligible extent by variations in the judgment of the individual who interprets the reports. A study of the validity of the ratings in terms of the relationship between chance halves of the reports indicates that such a high degree of agreement is attained that the *summarized ratings may be considered an acceptable basis for individual* recommendation with regard to favorable acceptance by others of the student's characteristics of social behavior

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THE INFLUENCE OF GENERAL SOCIAL STATUS ON THE EMOTIONAL STABILITY OF CHILDREN*

The Adolescent Court of Brooklyn

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INTRODUCTION

The rôle played by the general social environment in the adjustment of the individual is still little understood. Brown (2, p. 575), in the standardization of his *Personality Inventory for Children,* states,

> Neuroticism does not predominate in any particular social or cultural group. Situations engendering nervousness in children may be encountered in any stratum of society.

He comes to this conclusion on the basis of a correlation of —.118±.003 between neurotic scores and socio-economic status, as measured by the Sims *Socio-Economic Score Card.* In a more recent study, Brown (4) reports that differences in emotional stability between racial-rural-urban groups are not a function of either locale or race. He finds that adjustment is closely related to socio-economic level. The higher the social level of the child, the greater is the probability of emotional stability. Springer (6) reports that behavior adjustment, as measured by teachers' ratings on the Haggerty-Olson-Wickman *Behavior Rating Schedules,* is closely related to the general social status of the individual. Children who come from middle class families make better and more satisfactory behavior adjustments, while those who come from a poor general social level show more maladjustment and undesirable personal characteristics.

Since Brown's recent results are not in accord with his earlier findings, an attempt is made in this article to study the influence of environmental differences on the emotional stability of children.

PROBLEM

The purpose of this study is to determine whether there are any

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differences in the emotional stability of groups of children from different social levels

The Tests

The Brown *Personality Inventory for Children* was used to measure emotional stability. This test was administered in the Spring of 1935 to a large number of school children, as part of a study of personality. The Goodenough *Drawing of a Man Intelligence Test* (5) was also given, in order to equate the groups and to study the influence of intelligence on neurotic scores As an objective check on the environmental factors, the occupational status of the children's fathers was rated on the Barr Scale (1).

The Subjects

This study was limited to native born, white, New York City public school children, ranging in age from nine to fifteen years, who were in Grades 4 to 9, inclusive. The experimental population consisted of 327 boys and girls, who lived in a poor neighborhood. This neighborhood is best characterized by its squalid slum tenements, heavy congestion of population, and its low general social status Adjoining this section are many factories and various commercial enterprises The population consists largely of a heterogeneous group of foreign born adults and first generation Americans Most of the adults of this neighborhood, who are working, are employed at unskilled or semi-skilled occupations. The school teachers and administrative officials, who participated in this study, were unanimous in the opinion that the experimental children came from poor homes, that were on the average, of a low general social status.

The control groups consisted of 473 boys and girls, who came from middle class families These children lived in a good residential neighborhood While this neighborhood is heavily populated, it is characterized by clean, modern apartment houses, and adequate park and recreational facilities With the exception of the neighborhood shopping centers, there is very little commercial activity in this section of New York Adjoining this neighborhood are other middle class residential sections. The population consists largely of a heterogeneous group of foreign born adults and first generation Americans. Most of the adults of this neighborhood are

employed in skilled trades, white collar jobs, own their own small businesses, or are of the professional group The school teachers and officials, who were in intimate contact with the children of the control groups, were unanimous in the opinion that the children came from a good social status, which could be best described as middle class

Information with regard to chronological age, intelligence score, and Barr Scale ratings of the experimental and control groups is given in Table 1 The mean age of the total experimental group

TABLE 1

PERSONAL DATA OF THE EXPERIMENTAL AND CONTROL SUBJECTS

	Group	Experimental Mean	*SD*	*N*	Control Mean	*SD*	*N*
Age in years	Boys	12 78	2 11	190	11 96	1.73	237
	Girls	11 23	1 59	137	11 65	1 70	236
	Total	12 13	2 06	327	11 81	1 71	473
Goodenough Intelligence score	Boys	30 93	9 64	168	31 42	9 09	215
	Girls	30 47	7 84	127	31 90	7 62	221
	Total	30 73	8 97	295	31 66	8 34	436
Barr scale rating	Boys	7 77	2 86	142	10 48	2 42	214
	Girls	7 89	2 83	115	10 05	2 16	219
	Total	7 82	2 85	257	10 27	1 72	433

is 12 13 years, while that of the total control group is 11 81 Both the experimental and control groups are very similar in regard to Goodenough intelligence scores The differences between the groups are less than one point. The greatest differences between the groups are found on the Barr Scale Ratings The parents of the boys and girls of the experimental groups receive mean ratings that are from 2.16 to 2.71 points lower than those received by the parents of the control groups Since the Barr scores are probable error values, these differences are large When the groups are compared in terms of the ratios between the Barr mean differences to their standard errors, the differences are found to be statistically significant and range from 7 to 12 times their standard error

The personal data shows that the boys and girls of the experimental and control groups are fairly similar in regard to age and intelligence. The Barr data confirms the claim that the children of the experimental groups come from poorer homes, of a lower general social status than that of the control group

The Results

The results of the comparison of the experimental and control groups on the Brown Personality Inventory are given in Table 2,

TABLE 2
Results of the Experimental and Control Groups on the Brown Personality Inventory

Group	Experimental Mean	Experimental *SD*	Experimental *N*	Control Mean	Control *SD*	Control *N*	M_{diff}	SD_{diff}	Critical ratio
Boys	21 03	17 64	190	14 52	11 10	237	6 51	1 28	5.09
Girls	24 22	19 71	137	14 68	9 94	236	9 54	1 68	5 68
Total	22 40	18 65	327	14 60	10 54	473	7 80	1 30	6 00

in terms of the mean, standard deviation of the mean, mean difference, standard error of the difference, and the critical ratio of the mean difference to its standard error. Separate comparisons are made for boys, girls, and the total boys and girls in each group

The sum of the atypical responses constitute the Brown neurotic score. The children of the experimental groups have mean neurotic scores ranging from 21.03 to 24 22, while the means of the control groups vary from 14 52 to 14 60. The standard deviations of the means are large and indicate that there is a wide range of neurotic scores and also overlapping of the scores of the experimental and control groups. The middle 67 per cent of the total experimental group receives scores between 4 and 41, while the middle 67 per cent of the total control groups scores between 4 and 25

The mean difference between the boys of the experimental and control groups is 6 51, for the girls, 9 54, and for the total 7 8. These mean differences are from 5 09 to 6.00 times their standard errors, respectively, and are of a high degree of statistical reliability. The conclusions to be drawn from these comparisons are that the experimental groups receive neurotic scores that are significantly higher and indicative of more emotional instability than the control groups.

When the results of this study are compared with Brown's norms (3, p. 2), the mean of the boys of the experimental group falls within the 7th decile, the experimental girls in the 8th decile, and the total experimental group in the 7th decile The means of all the control groups are in the 5th decile According to

Brown's classification, the children of the experimental groups make a "poor adjustment" while the controls fall within the "average adjustment" category

Influence of Sex on Neurotic Scores

Brown (2, p 575) reports that his inventory appears to be equally applicable to both sexes An examination of the results of the present study (Table 2) shows that the boys of both the experimental and control groups receive mean scores that are slightly lower than those received by the girls These mean differences, however, are statistically unreliable and insignificant, as are indicated by critical ratios of 1 5 and 1 86, found between the boys and girls of the experimental and control groups, respectively

Correlations between Neurotic Scores and Other Factors

The relationships between the Brown neurotic scores and chronological age, intelligence, and Barr rating were determined by the correlation technique for the total experimental and control groups The results are tabulated in Table 3 The correlations are low

TABLE 3
BROWN NEUROTIC SCORES OF THE TOTAL EXPERIMENTAL AND CONTROL GROUPS CORRELATED WITH CHRONOLOGICAL AGE, INTELLIGENCE, AND BARR RATING

Measures correlated	Experimental r PE_r	Control r PE_r
Brown neurotic score with		
Chronological age	132± 036	064± 030
Intelligence score	027± 034	107± 033
Barr rating score	— 007± 043	070± 033

and indicate that the Brown neurotic score is not influenced by age, intelligence, or parents' occupational status These findings are very similar to those reported by Brown

Reliability of the Brown Inventory

Brown (2, p 573) reports uncorrected reliability coefficients ranging from 755 to 866 for the halves of the inventory. When the Spearman-Brown prophecy formula is applied, the corrected correlations range from 860± 010 to 928± 006 Reliability coefficients for the children of this study were calculated. Uncorrected r's ranging from 933 to 943 are found for the children of the experi-

mental groups and for the control groups, the uncorrected r's range between .801 to .852. Corrected coefficients for the entire scale vary from .965± .003 to .971± .003 for the experimental groups and .878±.010 to .920± .007 for the controls. These reliability coefficients are high and very similar to those reported by Brown.

Significant Items on the Brown Personality Inventory

The individual responses on the items of the Brown were studied for the total experimental and control groups. The percentage of symptomatic responses on each item was calculated, and the significance of the percentage difference for the experimental and control groups was then calculated in terms of the standard error of the difference. On 53 of the 80 items, the percentage of symptomatic responses of the children of the experimental groups is larger and statistically significant, i.e., the critical ratios are 3.00, or more. On only two questions, "Does a scolding make you feel badly," and "Have you been told at home that children should be seen and not heard," do the control groups receive significantly higher symptomatic scores.

An attempt to classify the neurotic responses of the experimental children shows that they give the greatest symptomatic replies to the questions in regard to physical symptoms, general social adaptation, home situation, school adjustment, and dreams. These are the same situations reported by Brown for children who make high neurotic scores.

Summary and Conclusions

The purpose of this study was to determine whether there are any differences in the emotional stability of groups of children from different social levels. The Brown *Personality Inventory for Children* was administered to an experimental group of 327 boys and girls, between the ages of 9 and 15 years, who come from poor homes of a low general social status. The experimental group was compared with a control of 473 children, who come from middle class homes. The children of both the experimental and control groups were comparable for age and intelligence. The parents of the experimental group received significantly lower ratings on the Barr *Scale of Occupational Status*.

When the central tendencies of the two groups are compared in

terms of the reliability of the difference, the mean neurotic scores of the experimental group are found to be significantly higher than those of the control The neurotic scores of the experimental group indicate that they present more emotional instability than the control group. When the groups are compared with Brown's norms, the experimental group is found to be poorly adjusted, while the control group makes a good average adjustment.

No reliable sex differences are found. The boys and girls of both the experimental and control groups receive neurotic scores that are similar

Low correlations, indicating the absence of any relationships are found between neurotic scores and chronological age, intelligence, and parents' occupational status High reliability coefficients for the inventory, similar to those reported by Brown, are found for both the experimental and control groups.

An item analysis of the inventory reveals that the experimental group gives more significant symptomatic responses on 53 of the 80 items, than the control group These neurotic responses can be classified as pertaining to physical symptoms, general social adaptation, home situation, school adjustment, and dreams

The general implications of the results are that emotional stability is closely related to the general social status of the individual. The children who come from a poor general social level are more maladjusted and emotionally unstable, than those who come from good, middle class homes The middle class group is more stable and makes a more satisfactory adjustment

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SEX REVERSALS IN THE MATING PATTERN OF THE RAT*[1]

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PURPOSE

The purpose of the present paper is to describe atypical responses observed during the conduction of a current investigation into the neural basis of the male copulatory pattern.

FEMININE RESPONSE IN THE MALE

Stone (1924) has described feminine mating responses exhibited by two normal and sexually active male rats The normality of the sex glands in these cases is attested to by the fact that one animal sired several litters, and a post-mortem examination of the testes in the second male revealed the presence of sperm in normal quantities

We have recently encountered a single case in which a normal male was observed to adopt the female copulatory pattern in response to the advances of a more aggressive male. When mounted by the aggressive animal the "feminine" male reacted by arching the back, and throwing the head upward and backward The response was exactly like the reaction shown by a female in heat but not highly receptive The arching of the back was sluggishly performed, and the sexual crouch was not held after the aggressive male dismounted

The "feminine" male responded to mounting by another male with the adoption of the female copulatory position in a total of nine instances within the space of one hour. Several of the atypical

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[1]The main investigation during which the behavior herein reported was observed was begun in the Laboratory of Physiological Psychology at Harvard University under the direction of Dr K S Lashley The early part of the study was supported by a grant from the Committee for Research on Problems of Sex, National Research Council

responses were noted by two independent observers called in from other laboratories.

When a sexually receptive female was thrown into the cage with the "feminine" male, the latter mounted and copulated with the female in normal fashion without delay. Upon one occasion the cage contained a receptive female, the "feminine" male, and a second male. Several times the second male mounted the "feminine" male, who adopted the characteristic feminine posture, and then, as soon as released by the other male, mounted and copulated normally with the female.

A vaginal smear taken from a female plugged by the "feminine" male revealed the presence of sperm, indicating that the male possessed normal testes.

Masculine Response in the Female

Assumption of the masculine copulatory pattern by the female is not uncommon in some animals Marshall (1922) has described the reversal of pairing positions in the Great Crested Grebe. Huxley also reports this phenomenon. C R Moore (1919), as well as Hemmingsen (1933), refers to the common occurrence of masculine behavior in female cattle

In spite of Moore's statement to the effect that masculine copulatory behavior has never been observed in connection with female rats in his colony, there are scattered references to such behavior in the literature. Hemmingsen (1933) observed two normal and three spayed female rats which mounted and palpated other females in heat In a personal communication from Dr C. P. Stone we have learned that he has observed masculine behavior in the normal females of his colony, but that in his experience these responses are extremely rare.

Long and Evans (1922) mention that "the female rat, unlike other mammals, only rarely attempts to play the part of the male in riding other females" (p. 71).

We have found in the literature no mention of *female rats mounting and palpating males*

In no instance do the reports in the literature describe a normal female rat as duplicating the entire male sex pattern. However, all of the elements except the post-copulatory backward lunge, the cleaning of the genital region, and the ejaculatory pattern have been described.

Seven sexually inexperienced female rats in our colony, have been observed to duplicate most of the elements in the masculine copulatory pattern. These animals were a part of the colony of 200 females maintained for use in copulation tests with experimental males.

The experimental room in which the colony has lived from the time of weaning is a room which is darkened all day and in which the lights burn each night from seven P.M. until seven o'clock the following morning. The result of this reversal of the normal light-dark rhythm is that the females come into heat in the day, rather than at night. This makes possible the conduction of copulation tests during the day (Beach, 1938).

In the seven females to be described, as well as in all females in the colony, a sterilizing operation was performed before any contact with a male was permitted. The upper tip of each uterine horn was ligated at a point adjacent to the fallopian tube. Normal sex cycles occurred in the females despite the uterine ligation and the twelve-hour shift in the heat rhythm. The animals continued to come into heat at regular intervals, and accompanying changes in the vaginal mucosa followed the usual cycle.

The procedure followed in selecting receptive animals to be used in the copulatory test will be described briefly because of its bearing upon the atypical behavior to be described.

Females most likely to be sexually receptive were chosen from the general colony on the basis of the appearance of the genital region (Long and Evans, 1922). The animals thus selected were thrown one at a time into a cage with an "indicator" male. Indicator males were non-experimental animals especially chosen for their sexual aggressiveness. If the female reacted to the male's advances with a prompt assumption of the copulatory crouch, and permitted copulation with no show of preliminary resistance, she was set aside to be used in copulation tests with experimental animals.

Every one of the seven females displaying masculine behavior was found, upon tests with the indicator males, to exhibit unmistakable signs of extreme receptivity. All such animals crouched immediately at the male's approach and received the male without any resistance.

In four of the seven cases to be described the indicator male was allowed only one mounting with the female. Records of the remaining three cases do not reveal the exact number of contacts with the indicator male but it is certain that three copulations repre-

sented the maximum amount of experience allowed these cases. It is important to note that one copulation (in the case of four females) and three copulations (three females) represents the total amount of sexual experience allowed these animals.

Since the atypical behavior in the case of all seven females was nearly identical it may best be described with an excerpt from our daily reports:

October 18, 1937

Male No 156	Female No 92
10 05 A M	Female dropped into observation cage containing male
10 11 A M	Male investigates female, sniffing at the vaginal region, biting weakly at the neck
10 15 A M	Male continues to investigate female, shoving her about the cage. Both animals display all signs of intense sexual excitement but the male never actually mounts and palpates the female.
10 16 A.M	Female whirls about, approaches the male from the rear and mounts and palpates actively. The forepaws of the female clasp and palpate the male in the dorso-lateral region and the female's pelvic region is moved in and out with the piston-like action characteristic of the copulating male After this brief display of masculine activity the female dismounts, without the typical masculine lunge, and does not clean the genital region
10 17 A M	Female responds to male's investigatory activity by crouching, arching the back, and vibrating the ears rapidly

In the test described above, this particular female mounted and palpated the male a total of seven times during the 15-minute observation period Others of the seven females displayed such activity from three to eleven times within a single test In no instance has the abnormal behavior described been observed in the sexually experienced female It seems to have been associated exclusively with the initial sexual contact.

We were so unfortunate as to lose three of the seven cases described above in the course of moving our experimental colony to a new laboratory The remaining four cases, however, are still in our colony and are used frequently in copulation tests with experimental males

In an attempt to accumulate additional evidence in support of our belief that these females are possessed of normal ovarian functions, we have conducted macroscopic examinations of the uteri and ovaries in the four cases still in our colony.[2]

The animals were etherized and the ovaries and uterus were examined through a longitudinal incision in the ventral wall. In several instances the ovary proved to be encapsulated, and the surrounding membrane in some cases was somewhat distended with fluid. This condition prevailed in both ovaries in two cases. In the remaining two animals, one ovary was encapsulated as described above and the other normal.

Hemmingsen (1933) describes ovarian conditions, similar to those observed in our animals, following hysterectomy of females in his colony. Long and Evans (1922) report that in the normal female the peri-ovarial membrane is frequently distended by fluid secreted during ovulation.

When the surrounding membranes were ruptured to permit inspection of the ovary it was found in all cases that the ovarian tissue appeared to be normal. Corpora lutea were frequently distinguishable. In one case a single ovary bore a small cyst.

Summary and Conclusions

One normal male has been observed to display the typical feminine copulatory response to the sexual advances of a more aggressive male. This "feminine" male has displayed normal masculine copulatory activity when placed with a female in heat.

Seven sexually inexperienced females sterilized by ligation of the uterus have been observed to respond to the non-copulating male with the adoption of the masculine sex pattern. These females, after reacting to the male's investigatory activity with all signs of extreme sexual receptivity, mounted and palpated the male only to return immediately to the feminine behavior pattern when the male assumed a sexually aggressive attitude. This atypical behavior has been observed only in virgin females. Four of the original seven cases have been used in copulation tests for four months subsequent to the initial experience in which they displayed masculine activity, but in no instance have these subsequent tests revealed any repetition of the abnormal behavior recorded in the first test.

[2]We wish to express our gratitude to Dr. E. B. Astwood who conducted the examinations of these animals.

The foregoing results might be taken to indicate that the specificity of the mating patterns for the two sexes, although probably inherited, is not rigidly dictated by the innately organized substratum. Although there may be a strong preference for the normal copulatory response it is obvious that in a few individuals at least, there exists the innate organization essential to the mediation of the mating pattern of either sex. The presence or absence of such duplicate arrangement within all individuals is a matter for speculation. It is obvious, however, that the mating behavior to be displayed by a member of either sex may be in part or (in the cases reported), entirely predetermined by the behavior of the partner.

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THE INTERRELATIONSHIP OF DRIVES IN THE MALE ALBINO RAT. III. INTERRELATIONS AMONG MEASURES OF EMOTIONAL, SEXUAL, AND EXPLORATORY BEHAVIOR*

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In a previous experiment (2) the writer obtained significant negative correlations between a measure of emotional defecation and various tests of sexual behavior and of learning performance. That is, rats which were the least emotional (timid) as measured by their amount of defecation in a novel situation were the most potent sexually and learned a maze more rapidly than rats which defecated a great deal in the emotional test. Since only one test of emotional behavior was included in the previous study it appeared desirable to determine whether or not different measures of emotionality would intercorrelate, and if such measures would show the same relation to sexual behavior as previously reported. The present experiment reports the intercorrelations among four tests of emotional behavior, two scores of copulatory activity, and one measure of exploration. These data were obtained in connection with a study upon the relation of the weights of the endocrine glands to behavioral measures (3).

A. ANIMALS, HOUSING, AND DIET

A group of 91 male albino rats was used in this study. The mean age of the animals at the beginning of the experiment was 131 days (range 126 to 134 days). The rats were housed in mesh wire cages measuring 13½ by 12 by 12½ inches (five animals per cage) and were maintained on a diet of dog chow supplemented weekly with fresh meat and lettuce. Food and water were always present in the animals' living cages.

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B Description of Tests

1 *Tests of Emotional Behavior.*

a Test 1 Emergence from living cage The living cages were made of mesh wire of the dimensions previously given In the center of the top of the cage was an opening 7 by 5 inches This opening was not closed by a door but escape was prevented by pushing the cage between supporting shelves For the present test, the cage was pulled out from the shelves far enough to allow the rats free egress from the cage. By climbing up the wire sides of the cage, the rats could escape through the opening in the top A stop watch was started when the cage was pulled out and the time recorded when a rat came out on top of the cage As an animal emerged he was picked up and placed in another cage until all of the animals of a given cage had thus emerged, or until the test was discontinued in the event that some rats failed to come out. The test continued for 20 minutes and if an animal had not come out of the cage during this period he was given the maximum score of 20 minutes. The test was repeated 8 times, with an interval of 7 days between each test The measure correlated consisted of the total time required to emerge from the cage for the 8 subtests, a high time score being assumed to indicate a relatively high degree of emotionality.

b Test 2 Emergence from stove pipe. This test was given in the apparatus described by Stone (6) The rats were placed in a small starting box and allowed to enter a dark U-shaped tunnel made of 4-inch stove pipe The total length of the tunnel was 72 inches The rats were taken from their living cages (which always contained food and water) and immediately tested in the stove pipe. To provide some motivation for leaving the stove pipe and entering the open reward box (which measured 18 x 7 by 6 inches) several more or less preferred foods (fresh meat, sugar, and a moist mash made from the stock diet) were placed in the reward compartment. Upon the first trial, the animals were allowed 10 minutes to complete their run If they had not entered the reward compartment within this time they were removed from the apparatus (by separating the stove pipe sections) and placed by hand in the reward box where they were permitted to eat. Upon all later trials the rats were thus removed from the stove pipe if they had not

completed their run in five minutes. A total of 10 trials, one per day, was given, and the score consists of the time (for 10 trials) required by the animal to go from the starting box to the reward box. Cases of failure to enter the reward box within the time limit were recorded as five minutes. A high time score is again assumed to indicate a relatively high degree of emotionality.

c. Test 3. Water-wading defecation. The rats were placed in a bottomless sheet metal box 12 by 10 by 13 inches high which was placed in a pan containing 1¼ inches of water. The top of the box was a sheet metal sliding door. The rat was thus wading in water in a dark box with no means of escape. The number of fecal boluses excreted during a 3-minute test period was recorded. Six tests were given with an interval of one week between tests, and then 10 more tests were given daily. The score is the total number of boluses excreted in the 16 subtests.

d. Test 4. Open field defecation. The rats were placed individually in a circular open field 90 inches in diameter and 30 inches high, and the number of fecal boluses excreted in a 3-minute test period was recorded. The test was repeated four times with an interval of four days between tests. The score is the total number of boluses excreted in the four subtests. This test is similar to that used by Hall (4) in studying emotionality in the rat.

2. *Tests of Sexual Behavior.* Since Anderson (2) has shown that the copulation test correlates significantly with other tests of sexual drive, sex measures of the present study were restricted to copulatory activity. To insure the male rats adequate opportunity for sexual experience before the time of the tests, males and females were caged together, new females being substituted for those which became impregnated. At 124 days of age the males were sex segregated; 13 days later a preliminary sex test was given. Only two copulations were permitted during this preliminary test. The purpose of the test was to determine the number of rats failing to copulate, and, since 54 per cent of the rats failed to show sexual activity, the non-copulating rats were given a series of 15 opportunities to copulate extending over a period of one month. As soon as a rat copulated on one of these preliminary tests, he was no longer tested. The preliminary tests had the desired effect of reducing the number of non-copulating rats, although 30 per cent of the rats failed to copulate at any time during the preliminary

tests. At 165 days of age the regular series of copulation tests was begun For these tests the animals were first activated in their living cages by being allowed one copulation with a female in oestrum[1] Fifteen minutes later a female in oestrum was again placed with the male and the 15-minute test period was started immediately Six such 15-minute tests were given with an interval of one week between successive tests Two scores were recorded

a. Test 5 Copulation The total number of copulations performed during the 6 subtests constitute this score

b. Test 6. Vaginal plugs The score is the total number of vaginal plugs delivered during the six copulation subtests of Test 5.

3 *Test of Exploratory Activity* Since the exploratory activity exhibited by a rat in an open field correlates significantly with other measures of exploration (2) only this test was used in the present study The measure consists of the activity exhibited in the open field situation and was obtained simultaneously with the open field defecation score To facilitate scoring, the floor of the field was divided by chalk lines into 9-inch squares

a Test 7 Open field exploration The score correlated is the total amount of exploratory activity as measured by the number of 9-inch squares traversed in the 4 subtests of the open field defecation test 4.

4 *Order of Giving Tests* The test schedule is presented in Table 1.

C. Results

1. *Mean Scores and Measures of Variability.*

a. Tests of emotional behavior Tables 2 to 5 present the means and ranges by subtests of the four tests of emotional behavior. All four of the measures show adaptation as the tests are repeated, that is, there is a tendency for the mean scores to decrease with successive subtests The adaptation is most marked and most regular with the open field defecation test Adaptation to the test situations is also shown in the increase in the percentage of rats not defecating in the open field and water-wading tests, and in the decrease in the percentage of rats failing to emerge in the stove

[1]Prompt and willing copulation with two indicator males was used as the criterion of a receptive female

TABLE 1

TEST SCHEDULE

	Test	Number of subtests	Length of subtest	Days between each subtest	Age (days) at 1st subtest	Mean weight (grams) 1st subtest
	Sex segregation				124	218
1	Emergence from living cage	8	1 trial	7	131	
	Copulation preliminary				137	231
5, 6	Copulation tests	6	15 min	7	165	246
3	Water-wading defecation	16	3 min	7 and 1	170	
4	Open field defecation	4	3 min	4	253	282
7	Open field exploration	4	3 min	4	253	282
2	Emergence from stove pipe	10	1 trial	1	276	284

TABLE 2

MEAN SCORES AND MEASURES OF VARIABILITY FOR THE EMERGENCE FROM THE LIVING CAGE TEST

All scores are in terms of minutes required for the rat to emerge. Maximum time allowed for each subtest is twenty minutes ($N = 91$)

	Subtests 1	2	3	4	5	6	7	8	Total score	SD_{dis}
Mean minutes to emerge	12.9	13.1	12.3	11.0	11.2	10.8	9.5	10.4	91.3	53.6
Range in minutes	5 to 20.0	3 to 20.0	3 to 20.0	2 to 20.0	2 to 20.0	2 to 20.0	1 to 20.0	2 to 20.0	7.1 to 160.0	
% rats not emerging	51	55	47	43	42	41	32	38	14	

TABLE 3

MEAN SCORES AND MEASURES OF VARIABILITY FOR THE EMERGENCE FROM THE STOVE PIPE TEST

All scores are in terms of minutes required for the rat to leave the stove-pipe and enter the reward box. Maximum time limit per subtest is five minutes ($N=91$)

	Subtests 1	2	3	4	5	6	7	8	9	10	Total score	SD_{dis}
Mean minutes to emerge	2.5	2.3	2.7	2.4	2.0	1.9	1.9	2.1	2.0	2.1	21.8	16.1
Range in minutes	3 to 5.0*	2 to 5.0	2 to 5.0	2 to 5.0	1 to 5.0	1 to 5.0	1 to 5.0	1 to 5.0	1 to 5.0	1 to 5.0	2.4 to 50.0	
% rats not emerging	36	34	42	35	31	24	23	26	29	30	8	

*Ten minutes were actually allowed on the first subtest, but for uniformity in scoring, the scores upon the first trial have been computed upon the basis of a 5-minute time limit

pipe and living cage tests. Of the four emotional behavior tests, the water-wading test is the best from the standpoint of the distribution of scores. No rat failed to defecate on at least one of the subtests in this test and the maximum per cent of rats not defecating on a particular subtest was but 13 per cent. These results are in contrast with the open field defecation test in which as many as 48 per cent of the rats failed to defecate on one of the subtests and

TABLE 4

MEAN SCORES AND MEASURES OF VARIABILITY FOR THE WATER-WADING DEFECATION TEST

All scores are in terms of the number of fecal boluses excreted. Each subtest is three minutes in length ($N = 91$)

	Subtests 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total score
Mean number of fecal boluses	6 1	5 7	5 7	5 4	5 6	5.5	5 9	5 2	4 8	5 7	4 8	4 9	4.9	4 8	4 9	4.3	84 3
Range in No of fecal boluses	0-13	0-11	0-11	0-10	0-9	0-10	0-11	0-9	0-11	0-10	0-12	0-10	0-10	0-11	0-10	0-9	9-120
% rats not defecating	1 1	1 1	2 2	4 4	1 1	3 3	2 2	4 4	9 9	5 5	12 1	8 8	9 9	11 0	13.2	12 1	0
SD_{dis}																	22 0

TABLE 5

MEAN SCORES AND MEASURES OF VARIABILITY FOR THE OPEN FIELD DEFECATION TEST

All scores are in terms of the number of fecal boluses excreted Each subtest is three minutes in length ($N = 91$)

	Subtests				Total
	1	2	3	4	score
Mean number of fecal boluses	4 3	3 7	2 7	2 5	13 2
Range in No of fecal boluses	0-13	0-10	0-9	0-9	0-31
% rats not defecating	21	31	47	48	16
SD of the distribution					9 3

16 per cent of the animals did not defecate in the total test The two escape tests also show large percentages of animals not emerging on certain of the subtests and a relatively large number never emerging upon any subtest.

The animals of the present group appear to be somewhat more emotional than other groups of rats with which the writer has worked In no case are the groups strictly comparable as to age or previous experience, hence the following comparisons are not conclusive. A group of 51 animals previously reported (2) averaged 2.8 fecal boluses upon the first subtest of an open field test (which had been preceded by tests upon a Dashiell maze and a vertical exploratory maze). The present group averaged 4 3 boluses upon the first subtest and did not meet the level of the previous group until the third subtest (mean 2.7 boluses) A second group of 54 male rats (1) averaged 2 4 fecal bolouses upon the first subtest of an open field test. This same group was also given a water-wading defecation test and averaged 3 2 boluses upon the first subtest, a figure which is below the average of the present group for any of the 16 subtests given in the water-wading defecation test

b. Tests of sexual behavior. The mean scores and ranges for the sexual behavior obtained from the series of six subtests are presented in Table 6 There is a gradual increase in the frequency of copulations and number of plugs delivered up to about the fourth subtest and then a relatively stable level is reached. There is also a decrease in the number of rats failing to copulate or to deliver plugs with successive tests The present group shows a lower mean copulatory frequency and a higher percentage of non-copulating rats than a group of 51 males previously reported (2). The males of the

TABLE 6

MEAN SCORES AND MEASURES OF VARIABILITY FOR THE TESTS OF SEXUAL BEHAVIOR

All scores are in terms of the number of copulations occurring or the number of plugs delivered. Each subtest is 15 minutes in length. (N=91).

Subtest	Mean No. of copulations	Range in No. copulations	% rats not copulating	Mean No. of plugs	Range in No. plugs	% not delivering plugs
1	5.7	0-16	26	.62	0-2	53
2	6.6	0-16	23	.76	0-3	45
3	6.6	0-18	22	.75	0-2	46
4	7.5	0-17	21	.92	0-2	38
5	7.5	0-21	21	.81	0-2	41
6	7.4	0-16	18	.80	0-2	42
Total score	41.2	0-84	16	4.69	0-13	29
SD_{dis}	24.6					

earlier study averaged from 10.3 to 12.6 copulations per 15-minute test for a series of four subtests and from 8.7 to 9.6 copulations upon a later series of three subtests, while the animals of the present study average from 5.7 to 7.4 copulations per 15-minute test. The groups are not entirely comparable as to age and previous experience. In spite of the reduced number of copulations, the present group delivered as many vaginal plugs as did the earlier group. In the previous study, an average of .73 to .90 plugs were delivered per test for the first series of tests and .51 to .88 for the second series, while the present group averaged from .62 to .92 plugs per 15-minute test. Many rats of the present group consistently delivered plugs after only 3 to 4 copulations. A reduction in the frequency of copulations is thus not necessarily accompanied by a reduction in the number of vaginal plugs delivered, although correlations of .65 to .79 have been reported between the frequency of copulations and the number of plugs delivered (2, 7, and the present study, Table 9).

c. The exploration test. The mean scores and ranges for the measures of open field exploratory activity are presented in Table 7. The amount of activity exhibited shows a gradual and consistent decrease as the test is repeated. The present group did not show as much activity as a group previously reported (2) which averaged 94 squares on the first subtest and 84 on the fourth subtest.

TABLE 7

Mean Scores and Measures of Variability for the Open Field Exploratory Test

All scores are in terms of the number of 9-inch squares tranversed during the test period. Each subtest is three minutes in length (N=91)

	Subtests 1	2	3	4	Total score	SD_{dis}
Mean	64.9	59.2	52.8	46.1	223.0	88.4
Range	2-115	0-130	0-126	0-129	22-452	

TABLE 8

Reliability Coefficients Obtained by Correlating the Scores Made upon the Odd Numbered Subtests with Those Made upon the Even Numbered Subtests (N = 91)

Test		Number of subtests	Score in terms of	Odd-even subtest r	Spearman-Brown r
1	Emergence from living cage	8	Seconds to emerge	.911	.953
2	Emergence from stove pipe	10	Seconds to emerge	.883	.938
3	Water-wading defecation	16	No. of boluses	.752	.859
4	Open field defecation	4	No. of boluses	.732	.845
5	Copulations	6	No. of copulations	.919	.958
6	Vaginal plugs	6	Number of plugs	.912	.954
7	Open field exploration	4	Squares traversed	.754	.859

TABLE 9

Intercorrelations among Emotional, Sexual and Exploratory Tests (N = 91)

Test	Name of test	2	3	4	5	6	7
1	Emergence from living cage	.401	.264	.485	—.511	—.578	—.035
2	Emergence from stove pipe		.296	.429	—.420	—.427	—.167
3	Water-wading defecation			.532	—.342	—.359	—.041
4	Open field defecation				—.420	—.516	—.022
5	Copulations					.786	—.127
6	Vaginal plugs						—.104
7	Open field exploration						

Standard errors of the above correlations

r	.00	.10	.20	.30	.40	.50	.60	.70	.80	.90
SE	.105	.104	.101	.095	.088	.079	.067	.054	.038	.020

2. *Reliability.* Reliability coefficients were obtained by correlating the sum of the scores made upon the odd subtests with the sum of the scores made on the even subtests. As Table 8 shows, the

corrected coefficients range from .85 to .96 and are well within the range of reliabilities reported for similar tests (2, 4, 5, 7),

3 *Intercorrelations* Table 9 presents the intercorrelations[2] obtained among the tests of emotional, sexual, and exploratory behavior.

a Intercorrelations between different measures of emotional behavior The four measures of emotional behavior (Tests 1 to 4) yield intercorrelations ranging from .26 to .53 All but the one correlation of .26 are statistically significant Thus animals which take a long time to emerge from their living cage also tarry a long time in the stove pipe and defecate more in the open field or when placed in a pan of wading-deep water. The open field defecation test yields the highest correlations with all of the other emotional tests

b Correlations of the sexual tests with emotional behavior. The frequency of copulations correlates from —.34 to —.51 with the emotional tests, while the vaginal plug correlations with emotional tests are consistently slightly higher, ranging from —.36 to —.58 All of these correlations are statistically significant. The sign of the coefficients means that rats which copulate the most frequently and deliver more vaginal plugs take *less* time to emerge from the living cage and the stove pipe and defecate less in the open field and water-wading tests than do rats which are not so active sexually. The highest correlations of the sexual scores are with the emergence from the living cage test It is possible that the two correlations involved here are somewhat spuriously high due to an artifact of the testing schedule The escape test was given during the same period as the preliminary sex tests (see schedule, Table 1). Since the technique of testing the sexual drive involved drawing the living cage forward on its shelf to introduce a female it is possible that the more active males became so conditioned that they expected a female sex object whenever the cage was so opened When the cage was drawn forward for the emergence from the cage test, therefore, the more active (sexually) males may have been stimulated to a quicker emergence by a conditioned and mildly aroused sex drive Correlations of the sexual tests with the other emotional measures do not involve the same possible artifact because

[2]All correlation coefficients reported in this paper are Pearson product-moment correlations calculated from grouped data

of the different methods of testing and because of the greater temporal separation between the emotional and sexual tests. In an earlier study (2) the writer reported correlations of —.40 and —.44 between a measure of emotional defecation and two series of copulation tests, and a correlation of —.50 between the defecation test and a vaginal plug score. Correlations of —.22 to —.42 were also obtained between the defecation test and four indirect measures of the sexual drive (such as the obstruction sex tests). The evidence thus clearly indicates a negative relation between sexual and emotional behavior which is obtained somewhat regardless of the particular tests used.

c. Correlations of the exploratory test with measures of emotional behavior. There is no significant relation between the amount of exploratory activity exhibited in the open field and the emotional tests, the correlations ranging from —.02 to —.17. This result is in agreement with that of an earlier study (2) in which no significant relation was found between a measure of emotional defecation and several measures of exploratory behavior. The correlation of —.02 between exploratory activity and the open field defecation test is of special interest since these measures are both derived from the same series of experimental tests. The amount of activity exhibited in the field constitutes the measure of exploration, while the number of fecal boluses excreted in the same field and during the same test period constitutes the measure of emotionality. Since the two measures appear to be unrelated, it is possible to study simultaneously the effects of various experimental factors upon two independent functions.

d. Correlations of the exploratory test with the tests of sexual behavior. Anderson (2) reported correlations of .32 and .35 between a test of open field exploration and two tests of copulatory activity, and a correlation of .17 between the exploratory test and a vaginal plug score. The present study yields correlations of —.13 and —.10 between the exploratory test and the copulation and vaginal plug score. The possible relation between exploration and sexual behavior indicated in the earlier study is thus not confirmed. The open field test of the earlier study was given during the same general time period as the copulation tests, although the two tests were not given on the same day. It is therefore possible that some indirect conditioning occurred which resulted in the exploratory

being in part determined by sexual factors, and thus the correlation might have been due to an artifact of the test

Correlation between the copulation frequency and vaginal e The correlation of 79 between these two sexual measures than that of .65 reported by Stone, Tomilin, and Barker l those of 68 to .74 reported by Anderson (2). The group of animals contained more non-copulating rats than ps previously studied, and since rats which do not copulate leliver plugs the slightly higher correlation of the present ay be due to this factor.

D Discussion

earlier paper (2) the writer reported significant intra-orrelations among different measures of exploratory be-ind among different measures of sexual drive Different the hunger drive and of the thirst drive failed to yield it intra-drive correlations. In an effort to account for the results, it was suggested that tests of drives which were y dependent upon internal conditions of the organism for ousal would fail to yield significant intercorrelations and s of drives which were primarily dependent upon external ns for their arousal should show significant intercorrela-In considering several implications of this theory, it was out that emotional behavior is externally aroused, and erefore, different measures of emotional behavior should elate (the earlier study contained but one test of emotional) In the present study, four different tests of emotionality ven for the purpose of testing the above hypothesis As clearly shows, the four tests do intercorrelate, the correla-volved ranging from .26 to 53 The results of the present e thus in agreement with the hypothesis previously presented. int correlations are obtained between emotional tests which inctly different in type and which involve entirely different of scoring In the stove pipe test, for example, the score rms of the number of seconds required by the animal to from a dark tunnel into an open and day-lighted box. In n field defecation test, however, the animal is merely placed ield and the number of fecal boluses excreted in a specified

period of time are counted. Regardless of this marked difference in test and score, the two tests yield a correlation of .43; that is, animals which do not emerge from a dark tunnel within a relatively short time tend to defecate extensively in the open field. The tests used in the present study have been described as tests of "emotional behavior," but it is probable that this phrase is ambiguous and that the behavior involved might be more adequately described as timidity.

The tests of sexual behavior appear to be as good measures of emotionality as do the emotional tests when the size of the correlations are considered, but the correlations are all negative. That is, animals which copulate frequently, take a relatively short time to emerge from their living cage or from the stove pipe and defecate little or not at all in the defecation tests. Significant negative correlations are obtained here between sexual and emotional tests which are separated by a temporal interval of over two months; a fact which indicates that the traits involved are relatively stable. Because of this stability of the traits, and because of the care taken to avoid frightening the animals in giving the sexual tests, it is improbable that the negative relation is due to any temporary or chance arousal of fear or a similar emotional state at the time the sexual tests were given. It is, however, possible that rats which are temperamentally "timid" are so easily aroused emotionally by any experimental procedures that other activities or behavior, not necessarily sexual, would be inhibited Negative correlations might then result from a somewhat general inhibition of activities in animals which are highly emotional. On the other hand, a negative relation might also result from an inhibition of emotionality by the presence of a strong drive, not necessarily sexual. These interpretations, one stressing the importance of emotionality, the other emphasizing drive, both imply that the negative relation between sexual and emotional tests is merely one case of a more general relation between drive and emotionality, and is not due to any specific relation between the mechanisms involved in sexual and emotional behavior. Opposed to these interpretations is the fact that the negative correlations obtained between emotional and sexual tests are considerably higher than those obtained between emotional tests and measures of other drives such as hunger, thirst,

ination[3] (2) A more or less specific relation between sexual otional tests is thus indicated; that is, the sexual tests cor- iegatively with emotional tests not simply because they are 's of *a* drive, but because they are measures of the *sexual* If, then, there is some specific relation between emotionality sexual drive, it is improbable that the obtained correlations adequately interpreted in terms of an inhibition of emotion 'e or an inhibition of drive by emotion It would thus to be more profitable to search for mechanisms which are ecifically involved in determining individual differences upon sexual and emotional behavior rather than for mechanisms are more general It is possible, for example, that the nega- ation may arise from antagonistic action of different parts of vous system, possibly from opposition between the sympa- nd parasympathetic divisions of the autonomic nervous system. i interpretation would apparently involve the assumption that uals differ with regard to the thresholds of excitation of these At the present time, however, the endocrine glands appear i somewhat more promising leads than does the nervous Elsewhere (3) the writer has presented some evidence of ion between the thyroid and pituitary glands in so far as their i to tests of sexual and emotional behavior is concerned. Al- that evidence is decidedly inconclusive by itself, it gains h because of its agreement with certain endocrinological data

pertinent data supporting this statement are summarized in the ig table

lations ween	Number of correlations	Range of correlations	Median correlation	Source
ial and l tests	8	— 34 to — 58	— 42	Present study
ial and atory tests	4	— 02 to — 17	— 04	Present study
ial and l tests	7	— 20 to — 50	— 40	Earlier study (2)
ial and ratory tests	7	+ 17 to — 33	— 02	Earlier study (2)
ial and tests	10	+ 26 to — 31	— 02	Earlier study (2)
ial and 'r tests	14	+ 17 to — 28	— 24	Earlier study (2)

It may therefore be that the negative relation between sexual and emotional behavior arises from interaction of the thyroid, sexual, and pituitary glands, or from some interaction between the thyrotropic and gonadal stimulating hormones of the pituitary gland and the ultimate effects of these hormones upon emotionality and the sexual drive Further experiments upon the relations of the endocrine glands to emotional and sexual behavior are in progress.

1 *Evaluation of the Different Methods of Measuring Emotionality* The open field defecation test yields the highest correlations with all of the other emotional tests and from this standpoint is probably to be preferred to the other tests, it also has an advantage in that a measure of exploration is readily obtained at the same time, and thus the effects of various factors upon two distinct and relatively independent functions may be studied simultaneously Unfortunately, the open field defecation test is subject to a serious disadvantage in that, with some groups of animals, adaptation to the situation is so rapid that a large percentage of the animals do not defecate at all after the test has been repeated once or twice. For studies of individual differences, some animals may thus be inadequately differentiated. Although the water-wading defecation test does not correlate as highly with the other emotional tests as does the open field defecation test, it is more suitable for some purposes. Relatively few rats fail to defecate and the distribution curve is therefore more nearly normal Since adaptation is less rapid the test may be successfully repeated many times Both of the defecation tests are subject to a further difficulty in that occasionally results might be interpreted as indicating a change in emotionality due to the experimental conditions, whereas they might actually be due to the effects of those conditions upon the mechanism of defecation without regard to the emotional aspect

The emergence from the stove pipe and from the living cage tests avoid this latter difficulty and correlate with other emotional tests as well as does the water-wading test Regardless of this, however, the writer does not consider either of the emergence tests as valuable as the defecation tests for general usage They are scored in terms of time and it is necessary to set a time limit for the test When this is done, relatively large numbers of the animals fail to complete the test. Those failing to complete their trial within the specified time period in the stove pipe test must be removed from the apparatus

by separating the stove pipe sections. Regardless of how carefully this may be done, the animal is almost certain to be excited by the process and thus some emotional conditioning may take place which will influence the subsequent scores. Rats which voluntarily enter the reward box, however, are merely picked up from this box; thus all of the animals given the test cannot be subjected to precisely the same handling. If the arbitrary time limit per trial is increased so that more animals voluntarily complete their run, the distribution becomes more markedly skewed and, in studies involving the comparison of groups, a very few rats taking a long time to emerge may have too much effect upon the mean score of the group. Because of the operation of unknown or uncontrolled factors, the scores of animals in either of the emergence tests appear to be subject to more fluctuations than occur with either of the defecation tests. In general, then, it appears that the defecation tests can be somewhat more adequately controlled than the emergence tests, and that therefore the effects of various factors upon emotionality can be most readily established by means of the defecation tests. If, however, the factors being studied may possibly have some effect upon the mechanism of defecation independently of emotionality, the results may well be checked by means of the emergence tests.

E. Summary

1. A group of 91 male albino rats was given four tests of emotional behavior, two of sexual behavior, and one of exploratory activity.

2. The four different tests of emotional behavior yield intercorrelations which range from +.26 to +.53. These results are considered in relation to a theory previously presented, and the different methods of testing emotionality in the rat are evaluated.

3. The emotional tests all yield significant negative correlations with sexual tests, the correlations ranging from —.34 to —.58. Several possible interpretations of this relation are suggested.

4. The test of exploration does not correlate with either the emotional or sexual tests.

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COMPARISON OF THE WOODWORTH-CADY PERSONAL DATA SHEET AND BAKER'S TELLING WHAT I DO TEST*

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A.

A comparative study (10) was made of two groups of girls of relatively equal intelligence but differing markedly in academic achievement. The two groups, 50 in each, were equated as to: (*a*) normal intelligence, (*b*) normal health, (*c*) Italian nationality, (*d*) American nativity, (*e*) residence in a typical Italian section of New York City, (*f*) school grade, 6*A* or 6*B* (*g*) age, 11 to 12 years.

The two groups differed markedly in academic achievement, namely, one group succeeded and the other failed in the standard school subjects as measured by the *Metropolitan Achievement Tests*.

The groups were compared primarily as to whether they manifested measurable differences in such phases of personality as a representative set of selected personality tests purport to measure.

The Woodworth-Cady *Personal Data* (12) and the Baker's *Telling What I Do Test, Advanced* (1), were two of the personality measures used in this study. The Woodworth-Cady *Personality Data Sheet* is a revision by Vernon M. Cady (3) of the Woodworth *Personal Data Sheet* (11). The latter is a test of psychoneurotic tendencies or of neurotic maladjustments in adults.

The Cady revision is an adaptation of this test for children. It was originally adapted by Cady for the purpose of measuring psychoneurotic maladjustment in boys. It is, in fact, a further modification of the expurgated and revised form by Mathews (7). Cady made a number of additional changes based upon the extent to which individual items differentiated children rated by other criteria as superior or inferior in emotional stability (9). This form consists of 60 questions.

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Cady arranged this test in two forms in order to determine reliability Both forms appear in two columns on the same sheet In one form the questions are stated directly. In the second form the idea of each question is repeated in negative form The first form was used in this study.

The score consists of the number of items answered in the direction of maladjustment There is no time limit. It requires about 30 minutes

The publishers of the test (Stoelting) do not issue a manual of directions or a key to answers. The test, however, appears in somewhat modified form in *Genetic Study of Genius* (9) together with directions Each question appears answered in the direction of normal adjustment. The same questions included in the Mathews revision of the Woodworth *Personal Data Sheet* and reprinted with norms, by Hollingworth (5), are answered in the direction of maladjustment. These sources were used for scoring the Woodworth-Cady questionnaire in this investigation

The *Telling What I Do Test* obtains statements from children concerning their attitudes towards a variety of situations which children commonly experience The test consists of 80 such commonplace situations Three alternative ways of reacting to each situation are given, one that is ideal, one that is neutral, and one that is relatively undesirable. The subject is asked to indicate which one of these reactions he would select. The three questions in each situation are arranged in mixed order so that the first answer would not always be the ideal one Behavior on this test is measured by behavior tendencies It is a test of social, ethical, and moral standards of behavior (2, 8). Incidents of daily life furnish the material The advanced form for Grades 7 and 9 was used in this study.

In Tables 1 and 2 respectively are indicated the statistical findings on the Woodworth-Cady *Personal Data Sheet* and the *Telling What I Do Test,* in relation to the success and failure groups in this study.

A study of the values in the above tables indicates that the Woodworth-Cady test differentiated the success and failure groups conclusively and that the *Telling What I Do Test* differentiated the two groups to the extent of there being a strong possibility of a true

TABLE 1

STATISTICAL VALUES OF SCORES ON WOODWORTH-CADY PERSONAL DATA SHEET

	Success G	Failure G
Range	2-29	8-32
Mean	15 94± 55	20 28±.52
Median	16 ± 68	19 ± 65
SD	5 83± 38	5 94±.36
N	50	50
Difference of means		4 34± 756
Critical ratio		5 75*

*The following interpretation of the critical ratio was used

CR of 1 or less—indicates that the two groups are as much alike as they are different

CR of 1 to 2—indicates a tendency to a true difference

CR of 2 to 3—indicates a marked probability of a true difference

CR of 3 to 4—indicates a strong probability of a true difference

CR of 4 and more—indicates conclusive difference

The quotient of the difference of the means by the probable error of the difference equals the critical ratio .

$$\frac{M^1-M^2}{\sqrt{(PEM^1)^2+(PEM^2)^2}}=CR$$

TABLE 2

STATISTICAL VALUES OF SCORES ON *Telling What I Do Test*

	Success G	Failure G
Range	182-229	164-233
Mean	209 2±1 17	203 18±1 45
Median	211.5 ±1 46	202 5 ±1 81
SD	12 27± 82	15 24±1 02
N	50	50
Difference of means		6 02±1 86
Critical ratio		3 269

difference Maladjustment on the basis of both tests was in the direction of the failure group.

To establish further the relationship between achievement success or failure and personality adjustment as measured by the Woodworth-Cady and the *Telling What I Do Test,* the bi-serial coefficient of correlation was computed (6) The two phases of achievement, namely, success and failure, were correlated with the scores on the two personality tests respectively The findings are indicated in Tables 3 and 4

The lower scores on the Woodworth-Cady indicated in Table 3

TABLE 3

BI-SERIAL COEFFICIENT OF CORRELATION BETWEEN SUCCESS AND FAILURE IN ACHIEVEMENT AND THE SCORES ON THE WOODWORTH-CADY PERSONAL DATA SHEET

Distribution of Woodworth-Cady scores	Success	Failure	Total
2- 5	1		1
6- 9	5	1	6
10-13	11	5	16
14-17	12	11	23
18-21	11	17	28
22-25	8	4	12
26-29	2	8	10
30-30		4	4
	50	50	100
	Bi-serial r = .64		

TABLE 4

BI-SERIAL COEFFICIENT OF CORRELATION BETWEEN SUCCESS AND FAILURE IN ACHIEVEMENT AND THE SCORES OF THE *Telling What I Do Test*

Distribution of Telling What I Do Test Scores	Success	Failure	Total
230-235		2	2
224-229	5	2	7
218-223	11	3	14
212-217	9	12	21
206-211	7	4	11
200-205	6	6	12
194-199	6	9	15
188-193	3	4	7
182-187	3	3	6
176-181		3	3
170-175		1	1
164-169		1	1
	50	50	100
	Bi-serial r = .37		

point to better adjustment. The bi-serial r of .64 indicates a substantial relationship between achievement success and better adjustment as measured by the Woodworth-Cady test.

The higher scores on the *Telling What I Do Test* indicated in Table 4 point to better adjustment The bi-serial r of point .37 indicates a considerable tendency toward a positive relationship be-

tween achievement success and better adjustment as measured by the *Telling What I Do Test*.

In order to further test the validity of the Woodworth-Cady and the *Telling What I Do Test*, as personality measures, the scores of each of the two tests, for each of the two groups, were correlated respectively with the scores for each corresponding group on the Stanford-Binet (Intelligence Quotients) and on the Metropolitan Achievement (total scores) The results are indicated in Tables 5 and 6

TABLE 5

CORRELATION COEFFICIENTS BETWEEN THE WOODWORTH-CADY PERSONAL DATA SHEET AND THE BINET *IQ*, AND THE METROPOLITAN ACHIEVEMENT BATTERY, FOR THE TWO GROUPS

	Success G		Failure G			PE	
	r	PE_r	r	PE_r	$Diff_r$	$Diff_r$	CR
Woodworth-Cady and Binet *IQ*	0004	093	—050	096	0504	134	37
Woodworth-Cady and Metropolitan Battery	—211	091	167	068	378	113	33

TABLE 6

CORRELATION COEFFICIENTS BETWEEN THE *Telling What I Do Test* AND THE BINET *IQ*, AND THE METROPOLITAN ACHIEVEMENT BATTERY

	Success G		Failure G			PE	
	r	PE_r	r	PE_r	$Diff_r$	$Diff_r$	CR
Telling What I Do and Binet	124	090	094	094	030	.130	002
Telling What I Do and Metropolitan	173	092	206	091	033	129	29

The figures in Tables 5 and 6 indicate that all the correlation coefficients were very low and that the differences between the correlation coefficients on the respective tests for the two groups were negligible and unreliable The critical ratios were all less than 1 00.

The negligible correlation coefficients of the tests correlated warranted the conclusion that the tests (correlated) measured different factors, namely, that there were no (or very nearly no) common or parallel elements in what the correlated tests measured This was true for both groups The Woodworth-Cady and *Telling*

What I Do tests evidently measure something other than intelligence or academic achievement

B [1]

The Woodworth-Cady *Personal Data Sheet* and the *Telling What I Do Test* were item analyzed This was done with the view of ascertaining what particular behavior forms or behavior tendencies included in these tests differentiated (and to what extent) between the succeeding and failing groups and which, if any, of such behavior forms or tendencies were common to both tests

The following method of item-analysis was used The number of children that answered each particular question in the direction of maladjustment[2] in each group was ascertained. This number was reduced to the equivalent percentage of the respective group. The difference and probable error of the difference (4) between the percentages for the two groups were determined and the critical ratio established.

In Table 7 is presented the number of each question in the Woodworth-Cady *Personal Data Sheet* with the critical ratio for

TABLE 7
THE NUMBERS CORRESPONDING TO THE QUESTIONS ON THE WOODWORTH-CADY PERSONAL DATA SHEET AND THE CRITICAL RATIO FOR EACH RESPECTIVE QUESTION

Q. No	*CR*	Q No	*CR*	Q No	*CR*	Q. No	*CR*	Q. No	*CR*
1	2 18	13	0 00	25	0 36*	37	0.42*	49	0 38*
2	2 88	14	0 96*	26	0 00	38	0 94	50	4 30
3	2 50	15	2 63*	27	123	39	0 94*	51	1 03
4	1.58	16	1 33*	28	1 35*	40	0 30*	52	0 62
5	4 06	17	2 13	29	0 60	41	0 48*	53	2 87
6	1 08*	18	0 73*	30	2.88	42	3.28	54	2 47
7	4 54	19	4 09	31	3 39	43	0 00	55	0 60
8	1 89*	20	2 96*	32	0.07*	44	2 06	56	0 00
9	1.00*	21	2 11	33	1 87	45	2 95	57	1.04
10	3 05	22	2 50	34	0 48	46	1 89*	58	1.04*
11	1.22	23	3 13*	35	0 00	47	3 01*	59	4 60*
12	2.24	24	4 74	36	4 48	48	3 07	60	0 13

*All starred figures in this report indicate maladjustment for the success group.

[1]The contents of this part of this article were not included in the original report of this study

[2]On the *Telling What I Do Test* only scores of 1 00 (complete undesirability were considered.

each respective question indicating the degree of reliability of differentiation between the success and failure groups.

In Table 8 is presented the number of each question in the

TABLE 8

THE NUMBERS CORRESPONDING TO THE QUESTIONS ON THE *Telling What I Do Test* AND THE CRITICAL RATIO FOR EACH RESPECTIVE QUESTION

Q No	*CR*	Q No	*CR*	Q. No	*CR*	Q No	*CR*	Q No	*CR*
1	1 64	17	0 00	33	0 27	49	0 00	65	0 00
2	2 60	18	2.19	34	3 29	50	0 00	66	2 00
3	3 29	19	0 00	35	0 53*	51	2 00	67	2 96*
4	3 02	20	2 31*	36	2 19*	52	1 00	68	0 00
5	2 00	21	0 53	37	1 10	53	0 00	69	2 00
6	1 63	22	0 53	38	0 00	54	2.00	70	0 00
7	2 31*	23	0 69	39	0 55*	55	2 00*	71	0 00
8	3.50	24	1 60	40	0 83	56	0 00	72	2 27*
9	0.48	25	0 00	41	0 70*	57	0 97	73	3 29*
10	2 19	26	0 60*	42	2 60	58	0 00	74	0 60*
11	2 31	27	2 60	43	2 00	59	1 00*	75	1 80
12	1 00*	28	0 00	44	0.00	60	2 12	76	1 64*
13	0 00	29	1 67	45	0 00	61	2.00	77	0 00
14	1 00	30	0 55	46	0 00	62	2 00	78	0 94*
15	0 53	31	1 10	47	0 55	63	1 10*	79	0 76*
16	1 63*	32	2 00	48	0 00	64	0 96	80	0 00

TABLE 9

FIFTEEN QUESTIONS OF THE WOODWORTH-CADY QUESTIONNAIRE THAT DIFFERENTIATE MOST BETWEEN THE SUCCESS AND FAILURE GROUPS

	Questions	Critical ratios
1	Have you always gotten along without being plagued or teased by other children?	4 74
2	Do you like to be alone?	4 60*
3.	Is your speech free from stutter or stammer?	4 54
4	Do you carefully avoid taking other people's things without their permission?	4 48
5.	Do you dislike to tease others until they cry?	4 09
6	Have you always been good enough to escape being arrested, fined or placed on probation?	4 06
7	Would you rather go to school now than go out to work?	4 54
8	Are you afraid of water?	3 28
9	Have you always escaped having a real fight?	3 13*
10	Would you rather be with those of your own age than to be with older people?	3 05
11	Have you always been free from nervous twitching of your head, neck, shoulders or other parts of your body?	3 07
12	Is it easy to get you cross over little things?	3 01*
13	Did you ever have the same dream over and over?	2 96*
14	Do you dislike being idle and lounging about?	2 88
15	Do your teachers tell you that you are too noisy or talk too much?	2 88

Telling What I Do Test with the critical ratio for each respective question indicating the degree of differentiation between the success and failure groups

In Table 9 are presented the 15 questions in the Woodworth-Cady Questionnaire that differentiate most between the success and failure groups The figures to the right are the critical ratios indicating the degree of reliability of differentiation

In Table 10 are presented the 15 questions in the *Telling What I Do Test* that differentiate most between the success and failure groups The figures to the right are the critical ratios indicating the degree of reliability of differentiation

TABLE 10

FIFTEEN QUESTIONS OF THE *Telling What I Do Test* THAT DIFFERENTIATE MOST BETWEEN THE SUCCESS AND FAILURE GROUPS

	Questions	Critical ratios
1.	Going to bed. (*a*) early every night, (*b*) sometimes late, (*c*) always go late	3 5
2	Eating (*a*) usually hurry, (*b*) eat very fast, (*c*) eat slowly	3 29
3	Talking about myself. (*a*) sometimes do, (*b*) always do it, (*c*) almost never do	3 29
4	Trouble at home (*a*) I never have trouble, (*b*) I sometimes have trouble, (*c*) I am always in trouble	3 29*
5	In games (*a*) I want many playmates, (*b*) I play alone, (*c*) I play with one person	2.96*
6.	When I lose a game: (*a*) I just quit, (*b*) don't care if I lose, (*c*) try harder next time	2 60
7.	Playing games. (*a*) like one or two kinds, (*b*) don't like any kinds, (*c*) like many kinds	2 60
8	Taking turn at game (*a*) let others be first, (*b*) always want to be first, (*c*) don't care when I come	2 60
9	Care of schoolbooks (*a*) not very careless, (*b*) mark them all up, (*c*) take good care of them	2 31
10	When I make mistakes (*a*) tell right away, (*b*) will not tell, (c) tell if found out	2 31*
11	In playing games (*a*) I sometimes quarrel, (*b*) I quarrel easily, (*c*) I never quarrel	2 27*
12	Taking more than my share (*a*) never do, (*b*) often do, (*c*) don't if watched	2 19
13	Having breakfast: (*a*) always have it, (*b*) eat it quickly, (*c*) never time for it	2 19
14.	After being absent from school (*a*) I give an excuse, (*b*) I try to get along without an excuse, (*c*) I give an excuse, if asked to	2 19
15	When I am asked to give (*a*) give, but don't care to, (*b*) I won't give, (*c*) like to give	2 15

An examination of the questions in Tables 9 and 10 indicate no common elements of behavior or behavior tendencies, with one exception, namely, the *preference* of *being alone,* which is characteristic of the success group on both tests. Answers in the affirmative to Question 2 in Table 9 and to Part (*b*) in Item 5, in Table 10, indicate a preference on the part of the success group to be alone. On the basis of the Woodworth-Cady Questionnaire, this preference appears to be statistically conclusive and on the basis of the *Telling What I Do Test,* the indication of such preference is markedly reliable statistically.

Summary and Conclusions

Two groups of girls, 50 in each, of relatively equal intelligence but differing markedly in academic achievement, were compared, among others, on the basis of the Woodworth-Cady *Personal Data Sheet* and on the *Telling What I Do Test.* The Woodworth-Cady Questionnaire differentiated the success and failure groups to the extent of complete statistical reliability ($CR = 5.75$) and the *Telling What I Do Test,* to the extent of there being a strong probability of a true difference ($CR = 3.269$). Maladjustment on the basis of both tests pointed in the direction of the failing group.

The bi-serial coefficient of correlation between success and failure, and the scores on the Woodworth-Cady and the *Telling What I Do Test* were .64 and .37 respectively.

Both tests were correlated respectively with the Stanford-Binet (IQ) and the Metropolitan Achievement Battery (total score). The correlation coefficients were negligibly small in all instances indicating no common or parallel elements in the tests correlated.

The Woodworth-Cady Questionnaire and the *Telling What I Do Test* were item-analized and the degree to which each question differentiated the two groups, in terms of critical ratios, was established (see Tables 7 and 8).

The 15 questions in each test that differentiated between the two groups most, were compared for common elements of behavior or behavior tendencies (see Tables 9 and 10). The only common element found was the preference to be alone on the part of the success group.

The latter finding appears to be significant and warrants further investigation. The tendency to be alone is generally considered

symptomatic of an introvert, inferiority or schizoid trend The tendency to be alone, appears to be true of the success group in this investigation. There is no apparent reason, however, for attributing introvert, inferiority or schizoid trends to this group of children. On the basis of the total scores of these personality tests the success group is markedly well adjusted as compared with the failure group. Thus the question suggests itself—Does not the tendency to be alone have a totally different or an added significance? Is it not a characteristic of the more self confident, the more self sufficient individual? Is it not characteristic of the person who entertains higher standards and is therefore critical of his surroundings? Does not such a person logically prefer his own company compared to the less satisfying or possibly retarding company of others?

In the light of the above findings, further investigation is warranted as to (*a*) the validity and reliability of the Woodworth-Cady Questionnaire and the *Telling What I Do Test*, as instruments differentiating between academically succeeding and failing children, (*b*) the validity and reliability, for the same purpose, of the particular questions[8] on these tests that differentiated between the two groups with complete or high reliability, (*c*) the significance of the tendency to be alone especially as characteristic of academically succeeding children

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INFANT SUCKING AND TENSIONAL BEHAVIOR*[1]

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A. HISTORICAL REVIEW

1. *Sucking*. Few experimental investigations have been made on the sucking of infants. In view of the widespread interest in sucking behavior manifested by students of physiology, medicine, psychiatry, psychoanalysis, psychology, etc., the amount of useful information on the subject is indeed meager. Historical surveys of studies of the sucking reaction have recently appeared in investigations by Jensen (37) and by Pratt, Nelson and Sun (52).

Although sucking generally functions with a high degree of co-ordination from the first day, this physiological process undergoes considerable improvement during the first month of life and it is likely that the improvement continues beyond this period. Canestrini (12, p. 65) says that "of all senses taste stimuli certainly yield the promptest reactions" in young infants. Koffka (41, pp. 85-86) states that infants who lack a cortex suck from birth. He claims that normal infants quickly perfect the act and quotes Preyer as setting the learning time at about two weeks. Sollier (41, p. 86) states that congenital idiots show no improvement in sucking. Kasahara (39) says sucking improves with practice. Jensen (37) also finds that sucking improves with age. He states that at the first feeding situation the infant may make excellent sucking responses of short duration. One infant did not suck at all at first, while another sucked well for 60 seconds. Another infant who

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[1]The study was conducted at the State Farm for Women, Niantic, Conn. The writer is especially grateful to Miss Elizabeth Munger, Superintendent, Miss Elsie Shearer, Assistant Superintendent, and Dr. Helen Ferguson for their interest and support in carrying on the experiment. The writer also acknowledges his indebtedness to Dr. Arnold Gesell for his assistance in the initiation of arrangements for the investigation. Dr. Clark Hull not only gave technical assistance but furnished part of the apparatus. The members of Dr. Hull's informal seminar made suggestions concerning the interpretation of the results.

could not coordinate sucking with swallowing on the first day improved rapidly in this respect for six days. The child usually has to acquire the ability to keep food down.

Bernfeld (6) says that sucking is sometimes awkwardly performed at first and that some infants have to be taught to feed. He refers to sucking as oral grasping, and states that infants not only suck objects which cannot satisfy hunger but continue to suck after they are fully satiated and even suck in the absence of stimulating objects Very early in life the child sucks to overcome hunger and then goes immediately to sleep. Later, because sucking itself is a pleasure and he desires to prolong this pleasure, the child stays awake. Once the infant has discovered pleasure in sucking, he begins to use his fingers, thumb, or fist for pleasure sucking. Pleasure sucking is largely a matter of tactual pleasure within the mouth, and is accomplished largely by rhythmic action of the tongue and the Magitot membranes of both jaws The importance of the mouth in early infancy is seen in the fact that the oral zone, the most primitive tactual organ, imparts the earliest information of objects

According to Auerbach (1) the mechanics of sucking change with age. Infantile sucking is accomplished by drawing down the lower jaw and thereby increasing the vertical diameter of the oral cavity. He states that for four or five months of life downward stroking of the lower jaw plays the principal rôle in sucking. At two to three years the lower jaw still operates strongly even in drinking at a cup, but another mechanism (presumably the thorax) is now coming to the fore, and jaw movements will gradually disappear until they are no longer noticeable. In adults sucking pressure within the mouth occurs through inspiration. Gesell and Ilg (26) describe the process of sucking as follows The lips seal the orifice of the mouth and compress the nipple The uvula closes the nasopharynx. When the lower jaw and tongue are depressed the latter contracts and channels This movement of the floor of the mouth increases the size of the oral cavity and diminishes its air pressure. These writers agree with Auerbach that the mechanics of sucking undergoes modification with age.

Cameron (11) in his discussion of sucking says that the main difficulties of the first week are mechanical. Success in feeding depends on the sucking power displayed by the infant. The sucking

apparatus of the newborn infant does not function perfectly, and the mother's breast yields milk only with difficulty. Strong effective sucking which empties the breast is not acquired at once.

Improvement in sucking power with age is clearly demonstrated in the results obtained by Herz (31) and Basch (4) According to the latter, sucking pressure of the two weeks' infant was about triple that at birth.

Sucking pressure of infants has been measured by several investigators Herz (31) classified infants according to body length and found that the negative pressure for air sucking ranged from 3-4 mm. Hg for the weakest (shortest) infants to 9-14 mm Hg for the strongest infants. Prematures recorded pressures of 2-3 mm. Hg. Basch (4) reports sucking pressures varying from 3-10 mm Hg. Creamer (16) got sucking pressures of 58-140 cm. H_2O (43-100 mm. Hg) at one time and 41-160 cm. H_2O at another. He explains that the low pressures obtained by Herz and Basch are measures only of single sucking movements. Creamer states that the pressure increases for the first few sucking movements of a sucking period Jensen's curves (37) also show this increase. Creamer found that the pressure required to obtain milk from the breast varied from 13 to 69 cm H_2O, and on the basis of this discovery classified breasts as easy and hard yielding. Babies fed slower at the breast than at the bottle, probably because they had to exert greater force (3-8 cm H_2O) in getting milk from the breast A child who sucked hard without getting any nourishment dropped off to sleep

TABLE OF NEGATIVE SUCKING PRESSURES

Investigator	Date	Pressure
Herz	1865	3- 14 mm Hg
Basch	1893	3- 10 mm. Hg
Pfaundler*	1899	7- 52 mm Hg
Creamer	1900	43-104 mm Hg
Barth	1914	60-150 mm Hg

*Cited by Barth

Barth's (3) apparatus consisted of a sucking cap (rubber nipple) which fitted closely over the mother's breast A rubber tube incorporated in the cap led to a mercury manometer. The infant sucked at the cap and registered the sucking curves on a kymograph. Some of the subjects experienced difficulty in adapting to the rubber cap

and others had trouble in breathing Each child appeared to have a certain pressure sucking level. Lazy suckers took milk sporadically, with no greater force or speed at the beginning of the feeding period than at the end Barth quotes Feer and Susswein (a reference we were unable to secure) as stating that normal infants absorb most of the food within the first five minutes. He distinguishes breasts as easy and hard to suck and compares his results in this respect with those of Creamer (16) and Basch (4).

Pressure required to empty breast

		Easy breast	Hard breast
Creamer	(1900)	1 cm Hg	5 cm Hg
Basch	(1893)	up to 4 cm Hg	5-6 cm Hg
Barth	(1914)	3-4.5 cm. Hg	7-8 cm Hg

Kashara (39) and Jensen (37) recorded sucking curves of infants feeding from bottles Although the apparatus used by Kashara was relatively simple he obtained excellent curves of sucking and swallowing His study shows that sucking curves of healthy infants are regular in form and continuous with a ratio of 1 or 2 sucks per swallow The curves of newborn infants show interruptions of the sucking activity Premature infants and those suffering from lack of nutrition give irregular interrupted curves Jensen presents sucking curves which show "differential reactions to taste and temperature stimuli in newborn infants." The carefully planned and dependable apparatus, the excellent control of stimuli and conditions attending their presentation, the painstaking preparation of the subjects, and carefully kept records, give great reliability to his results Sucking reactions to the various taste and temperature stimuli were compared with the control sucking reactions to milk at a temperature of 40° C Jensen's curves show that infants tend to maintain a suction pressure on the nipple during rest periods and during periods of thwarting. Thwarting consisted in pulling the hair, holding the nose, pinching the toe, and altering the temperature or taste of the liquids. Frequent reference to Jensen's study will be made throughout this paper.

Sucking is not a function of hunger alone The infant sucks objects which are wholly inadequate to satisfy his hunger. Even a hungry infant will stop crying to suck non-nutritive objects for short intervals and, in spite of word to the contrary (10, p 45),

some hungry infants will suck these objects for several minutes with apparent satisfaction Creamer (16) forced a child to suck hard without getting any milk The baby went to sleep in the process. Infants suck at objects near them, viz, blankets, clothing, toys, their fingers, thumbs, etc They suck their own tongues and make sucking movements with the lips when, as far as can be determined, no stimulating object is present These sucking reactions often occur when least expected—when the infant is satiated or asleep In this connection, Pratt, Nelson and Sun (52) report that 49 per cent of sleeping infants gave sucking responses to stimulation of the lips and 40 per cent to stimulation above the lips Again, infants suck for long intervals without swallowing—a fact which indicates that although these two functions are closely associated, swallowing is not essential to sucking Because of its frequent dissociation from food-getting significant psychoanalytic implications have been ascribed to sucking

2 *Tension* The sucking activity and the grasping reflex are probably practiced in uterine life (24, 32, 54, 55, 65). It is largely because these two reflex activities (sucking and grasping) function so similarly in their display of energy that in this investigation they are studied in parallel Both activities are conspicuously vigorous early in life. Cutaneous sensibility is high in both lip and palm regions A close functional relationship exists between these parts. The hand to mouth reaction is probably the earliest perfected distal-proximal movement Both activities apparently function with great force during hunger and with relatively little strength at satiation (28) Finally, these activities lend themselves readily to simultaneous experimentation without interference with each other

At birth the mouth is superior to the hand in what might be called directed activity and definiteness of function. Upon proper stimulation the mouth can both open and close and with the aid of head and neck movements institute a strenuous search for the stimulating object. The hand can close upon palmar stimulation, but only infrequently (fortuitously) open in response to any form of stimulation; and it would be stretching a point to state that the hand actually searches for a stimulating object in a manner comparable with that of the mouth In addition, the function of the mouth in early infancy is fairly clear (52, 53), that of the hand, uncertain

It is known that "marked activity in one set of muscles—the use of the leg muscles in long walks, for example—will diminish the amount of work obtainable from other muscles, such as those of the arm" (33, p 51) The loss of energy by the remote muscles is probably due to the work done by these muscles in support of the major activity Now the sucking activity is accomplished principally by the action of muscles in the oral region. However, the entire skeletal musculature apparently adjusts itself to attend and abet the activity. Thus it is probable that changes in the amount of energy expended by the specific muscles engaged in carrying on the sucking activity are accompanied by corresponding changes in the tension of the skeletal musculature If this assumption be true, strong sucking will be attended by strong muscular tension, weak sucking by low tension. Resting between sucking periods will show the muscles enjoying relaxation. Observation of infants during the feeding period appears to confirm these statements. The principle of "pluri-muscular combination" (17, pp 128-129) probably extends to the sucking activity

If the tension of the body musculature varies directly with the strength of the sucking activity, a record of the changes in tension of a small group of muscles, such as the finger flexors, during this activity might well be indicative of the changes in tension of the total skeletal musculature Furthermore, gripping responses during periods of contented sucking and during periods of thwarting may be expected to assume definite characteristic patterns which contrast strongly with each other and are indicative of the somatic tensions attending these periods In this connection Kempf (40, p 561) in discussing the tonus of somatic muscles in their relation to viscero-afferent impulses states that Cannon and others supply physiological evidence "of characteristic streams of afferent nerve impulses giving characteristic cravings and emotional feelings or affective tone, from characteristic degrees of tension and distension of different visceral segments."

Studies of muscular tension during changes in affective state have been made by several investigators Among the experiments which particularly concern this study are the following. Titchener (63, pp. 149-171) presents experiments in which the form and direction of involuntary arm movements registered by an automatograph and the strength of pull on a dynamometer were used to indicate the

physiological changes accompanying changes in affective consciousness In the dynamometer test the typical strength curve for highly pleasant stimuli shows an immediate drop followed by a rise to a point exceeding the level of the normal curve Very unpleasant tastes are accompanied by a sharp drop followed by a slight recovery in pulling strength. Totten (64) found that in 6 of 14 experiments wherein emotional states were induced in adults there was an increase of oxygen consumption at the time the emotion was in force Muscular tension in arms and legs was noted

Johnson (38) studied the relation of temperament to "tension of expressive muscles" by recording alterations in finger pressure applied to a special form of stylus with which the subject tapped at maximum speed Duffy (21) instructed her subjects to press a key only when a red light appeared During the task a kymographic record was taken of the muscular tension of the other hand by its pressure on a rubber bulb She found that tension so measured "is correlated with excitability" and that "the type of tension line seems correlated with certain reaction tendencies of the individual and may be held to reveal certain of his temperamental characteristics" In another study (22) in which she experimented with discriminative reactions and with tapping Duffy found that subjects showed marked individual differences in muscular tension High tension individuals apparently "rated lower on stability and degree of adjustment to the environment" and tended to "press the reaction key with greater force." Chase (14) used a motivation dynamometer for recording the strength of grip and found that children who have scored a previous success in the performance of a task tend to work under greater tension under failure than under success in a different task

It is generally held that muscular tension increases during mental work (7, 44), and that tension increases the efficiency in performance of mental tasks (7) However, Zartman and Cason (71) find that the relationship between muscular tension and mental efficiency appears to be negative and point out that several other investigators also disagree with the general rule Luckiesh and Moss (48) found "a correlation between illumination intensity and nervous muscular tension resulting from visual effort" Variations in tension were determined by recording changes in pressure by the fingers of the left hand on the knob of a concealed key The results showed

that muscular tension attending reading at 1, 10 and 100 foot candles respectively, decreased as the intensity of illumination was increased

Russell (57) studied the "relative efficiency of relaxation and tension in performing an act of skill" by requiring subjects to toss tennis balls at a target under three conditions of tension for the arm He found an inverse relation between tossing accuracy and degree of muscular tension However, the warming-up effect within a trial varied directly with tension.

When an infant is confronted with a situation which calls for the expenditure of energy, muscular tension at such a time will be diffuse Watson and Morgan (67) state that stiffening of the body was the most frequent response to arm restraint. Taylor (60) found that restraining the movements of the arms of young infants resulted in much generalized activity in which leg movements predominated Trunk and head movements were also of frequent occurrence. Dockeray and Rice (20) found that responses to pain stimulation consisted largely of general "mass" movements Watson (66) says that limiting or hampering the freedom of body movements in infants is a natural stimulus to rage

In discussing reactions of the neonate, Pratt, Nelson and Sun say (52, p 208),

> Its behavior, however, is generalized, that is, stimulation of almost any group of receptors by almost any kind of stimulus will lead to a response in almost any part of the organism The reaction tends, however, to manifest itself most strongly in that part of the organism which is stimulated, and from there spreads out with decreasing frequency and intensity to the other segments of the body

According to Pratt (53), Irwin (34, 35) and Richards (56) bodily activity of the neonate increases as the next feeding period approaches "The general activity spreads so that almost all of the musculature of the body is in action" (53, p. 200).

In passing, Levy (46) in his experiment with young dogs states that short time suckers showed a greater and a more prolonged tendency to suck at objects between meals than did long time suckers. He assumes in human infants, as well as in dogs, a sucking phase of a certain duration. Lack of sufficient sucking activity leaves the sucking apparatus in a state of tension In order to attain a state of complete release of tension at feeding periods

sufficient means must be provided for satisfying the craving for both food and sucking.

B. The Object of the Experiment

Inasmuch as a great part of the waking life of the young infant is occupied with the acquisition of food, the present study is concerned with the nature and strength of sucking reactions at feeding time and also with the emotional and physical reactions which are associated with hunger and feeding responses.

Specifically the problems are: (*a*) To measure the strength and duration of sucking responses at feeding time under conditions wherein the child obtains nourishment and wherein he obtains no nourishment, under conditions wherein nourishment is obtained easily and wherein it is obtained with difficulty, and under conditions wherein the feeding process is delayed or interrupted. (*b*) To find the relation of body tension, as reflected in gripping pressure, to sucking under the above conditions and to interruptions in the feeding process. (*c*) To determine changes in sucking pressure, gripping pressure, posture and emotion during sucking, resting, and withholding of the nipple. It will be noted that the situations described are controlled presentations of situations which occur in the everyday experience of the infant.

With bottle babies sucking records include sucking air through an easy nipple, sucking milk through an easy nipple, and sucking milk through a difficult nipple. Sucking records of breast babies were obtained principally at the mother's breast; however, a few records of air sucking were also obtained from these babies. Withholding the nipple was practiced in the instance of all babies. Only two feedings were recorded in full: one of a bottle baby and one of a breast baby. The latter infant fell asleep during the feeding and did not awaken during his trip back to the nursery.

As the experiment proceeded it was found that close adherence to the procedure of feeding and hampering could not be mantained with all infants. Therefore when the emotional excitement for any infant reached a point at which it was inadvisable to follow the prescribed procedure, the thwarting situation was immediately discontinued and the nipple restored to the infant. It was found

necessary to follow this precaution more frequently with breast babies than with bottle babies.[2]

C. Apparatus

The apparatus for bottle babies consisted of hygeia bottles and nipples (6 easy and 6 difficult nipples), an extension kymograph with 10-inch drums (carrying paper about 72" long), 2 mercury manometers, a hand capsule and 2 markers. One manometer registered sucking pressure. It consisted of a double U-tube, each U about 12 inches in height. One U-tube contained the mercury (height of column 6") and the other contained water. The free end of the U-tube containing the water communicated with the hygeia nipple by means of a rubber tube and a fine burette-like glass tube, the small end of which was attached to the special small rubber tube of the nipple.

Holes were made in the nipples, one at the tip of the nipple and the other near its margin. A small rubber tube (3 mm in outside diameter) was drawn through the marginal hole inside the nipple and then through the other hole (see Figure 1). The tube was trimmed off flush with the tip of the nipple and then cemented (U. S. Rubber Co. cement) to it at the two holes so that the nipple was air tight in these places. New holes through which the milk flowed were now put in the end of the nipple by means of a hot needle. The nipple could not collapse under pressure. The tip of the nipple then contained two kinds of holes, the opening of the small rubber tube which communicated with the mercury manometer and the holes through which the infant sucked the milk from the bottle. An L-rod of steel with its disked end inserted into the free end of the mercury U-tube floated on the top surface of the mercury. This steel marker rose and fell with the mercury column and registered the sucking pressure on the paper of the kymograph.

The second mercury manometer with its marker registered the gripping pressure. This apparatus consisted of a small sensitive rubber capsule, 4½ x 2 x 1 cm. (when inflated), which lay within a silk sheath. The sheath prevented distention of the capsule. The

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[2]Gesell and Ilg (26) give a thorough description of the feeding behavior of infants throughout the first two years of life. The section on "Weaning and Transitions" (pp. 117-121) presents an excellent discussion of infants' preferences for breast and bottle.

capsule was connected by means of a thick walled rubber tube with the mercury manometer. A T-tube and air valve provided control of the air pressure within the gripping pressure apparatus. In order to inflate the capsule, air pressure of 6 mm. Hg was constantly maintained within the apparatus. Therefore, if one is interested in exact measures of pressure, 6 mm. Hg should be added to all records of gripping pressure appearing in this paper. An electric time marker operating at intervals of 15 sec. and a signal marker completed the recording apparatus.

The above apparatus with the exception of the bottle and nipple was also used for breast babies. A small 3 mm. tube from the first mercury manometer was held snugly against the mother's breast. The end of the tube which was held in place by the mother lay just at the end of the nipple. The baby's mouth closed on the nipple and the tube simultaneously. According to the mother's reports and our observations, the babies reacted to this situation just as they reacted to the breast without the tube.

D. Records

In addition to the kymograph records, observations were made on the following kinds of behavior:

General activity of infant: trunk, arms and legs.

Changes in posture during resting, sucking, waiting, and withholding the nipple.

Tenseness of musculature: arms, legs, abdomen.

Evidences of emotion: crying, fretting, restlessness, irritability, smiling, calmness, etc.

Nature of the sucking movements.

Body tension during strong, weak, irregular sucking, and mouthing.

Records of the infants include the condition of the diapers (dry, wet, soiled) before the infants were undressed, and whether or not micturition occurred during the nursing period. Although crying before the feeding period was of frequent occurrence, this behavior always ceased during removal of the clothes or on transfer to the experimental room. Hence, no difficulty was experienced in the preparation of the experiment.

The frequent appearance of penial tumescence made it necessary to record and study this behavior as follows:

1. Tumescence and coincidental activities
2. Detumescence and coincidental activities

Photographs of sucking and related responses were not taken during experimentation. However, when the study was completed and the behavior could be predicted, the experiment was repeated with two infants for the purpose of photographing the behavior. In both instances the photographs fully confirmed the conclusions drawn from this study.

E. Calibration of Nipples

The pressure required to force water at a temperature of 45° C. through the difficult nipples was determined as follows. A glass tube was inserted and sealed in a hole bored in a hygeia bottle near its bottom. The water was put in the bottle and the nipple attached. The bottle was turned upside down to the position in which bottles were presented to the children. A pressure bulb which communicated with a graduated mercury manometer was connected with the glass tube of the bottle. The amount of slowly applied pressure required to force the water through the nipple was obtained by observing the manometer reading at the moment when water was first detected emerging from the nipple. Twenty trials with each of the nipples were made at the beginning of the experiment. At the close of the experimentation the nipples were again tested (10 trials each). No other tests of nipple resistance were made, although each nipple was carefully examined before it was used. The easy nipples were tested in similar manner. If water

TABLE 1
CALIBRATION OF NIPPLES
DIFFICULT NIPPLES. PRESSURE IN MM HG REQUIRED TO FORCE WATER AT TEMPERATURE OF 45° C THROUGH NIPPLE

	Before experiment began		At end of experiment	
Nipples	Average pressure	Pressure range (20 trials)	Average pressure	Pressure range (10 trials)
1	11.4	9-15	10.2	8-14
2	10.7	9-15	10.0	8-12
3	9.3	7-13	8.2	7- 9
4	10.4	8-13	10.4	9-11
5	8.1	6-11	8.0	7-10
6	9.8	7-14	10.3	8-13

could be forced through the nipple at a pressure of 2 mm. Hg or less, it was judged an easy nipple[3] (see p. 368)

F. Procedure

The baby was completely undressed before he was brought to the experimental room, the temperature of which was about 85° F. A light blanket covered the baby until the experiment began. He was placed in a crib with a double pad and sheet immediately under him. An extra mattress served to raise him to a convenient level with respect to the apparatus. Breast babies reclined on the mother's lap during the experimental period. In order to disturb the baby's posture as little as possible during feeding and withdrawing the nipple, the mother leaned forward so that her breast was above the baby's face. To remove the nipple from the baby, the mother merely assumed an upright position. When everything was ready, the top blanket was removed and the rubber capsule was placed in the right palm so that all finger tips, except the thumb tip, closed on it. The kymograph was started and a 2 min. record of gripping pressure without sucking was first recorded. From here on the procedure varied. For one infant the easy nipple would be withheld for two minutes before he was permitted to feed from it. Later the difficult nipple would be substituted for the easy nipple, then the easy nipple given again and after a time withdrawn. Thus the infant might suck at the easy or difficult nipple three or four times at one feeding period. Similarly, a bottle or breast baby might have the nipple withheld or withdrawn (both listed in Table 6 as "withheld" or "removed") three times at one feeding period.

Thus it is found that:

In 29 instances gripping pressure alone (withholding the nipple) was continued for two minutes.

In 21 instances air sucking from the bottle for 2-9 minutes followed the 2 min. gripping pressure record. In 18 of these instances the bottle was removed for two minutes and then restored to the infant.

In 17 instances there was milk sucking through the easy nipple for 2-9 minutes. In three of these instances the nipple was removed

[3]Nipples which yielded milk too easily were tried and discarded. When milk escapes through the nipple under its own pressure, the child is usually upset. Milk overflows the mouth and choking and crying frequently occur.

after two minutes, withheld two minutes and then restored to the infant

In 29 instances two minutes of easy sucking of milk was followed by four minutes of difficult sucking of milk (Changing of nipples required about 10 seconds)

In 15 instances breast feeding of two minutes was followed by a period of one minute during which the breast was withheld

At all bottle feedings the experiment ended with the infant sucking milk from the easy nipple or his own bottle (his regular nursing bottle and nipple) Similarly, breast infants were permitted to suck without further interference during the remainder of the feeding period. Recording in each case continued until the kymograph paper in use was exhausted. The bottle milk used in the experiment was the infant's portion of the regular supply of milk used for feeding the infants of the hospital. The temperature of the milk at the start of the experiment was 42° to 45° C. During the experiment the temperature often dropped to 37° C and infrequently as low as 32° C No differential sucking reactions to these changes in temperature were obtained

Continuous records of the types of behavior studied vary from 30 seconds to 9 minutes. All measures in Tables 2, 3, 4, and 5 refer to complete records of a particular kind of feeding, not to a portion of the feeding period For example, if an infant sucking at the breast has the nipple removed three times during the course of the sucking period, according to the above tables there is only one feeding period Similarly, if a bottle baby sucking at the easy nipple has his feeding interrupted three times by withdrawal of the nipple or substitution of a difficult or dry nipple, there is only one easy feeding period

The subjects used in this study were 10 male infants With one exception (*Lon*) all were sturdy and alert. Their records credit them with a vigorous grasping reflex Six of the infants were fed entirely from the bottle, three from the breast, and one from breast and bottle. Their ages ranged from 1 to 43 weeks

Records were taken which covered 30 feeding periods. Some of the infants were used only once; others were used several times Some of them were used twice on the same day at different feeding periods. *Lau, Lon,* and *Fis* vere followed over several weeks (see

TABLE 2

INDIVIDUAL MEASURES OF SUCKING AND GRIPPING IN THE INSTANCE OF THE DRY NIPPLE

Name	Condition of diapers before experiment Dry (D) Wet (W) Soiled (S)		Age in weeks	Feeding hour	Time allowed for sucking (Sec.)	% of time spent in sucking	Short or long sucking periods	Time range of sucking periods (Sec.)	Range of sucking pressure (mm Hg)	Median sucking pressure (mm Hg)	Range of gripping pressure (mm Hg)	Median gripping pressure (mm Hg)
Pow	W		1	1 p m	450	70	L+S	2- 36	3-10	8	3-16	8
Aur	W		3	1 p m	410	95	*L*	5-171	1- 8	4	0-10	2
Obl	W	M[1]	3	9 a m	390	60	L+S	3- 15	9-15	11	9-18	16
Lan	W		6	1 p m	440	20	S	1- 8	0- 3	2	0-17	6
Aur	S		7	9 a m	350	60	L+S	2- 19	2- 9	7	4-17	6
Lan	D	M	8	5 p m	130	50	*S*+L	1- 13	1-11	7	0- 5	1
Lan	D		9	1 p m	230	30	S	1- 13	1-13	7	0-13	4
Fis	W		11	1 p m	645	98	L	3- 32	1- 8	2	1-12	4
Lon	D	M	11	1 p m	375	10[2]	S	1- 4	1- 3	2	1-11	3
Fis	W		12	1 p m	395	10	S	2- 24	8-15	10	0- 4	2
Lon	W		12	1 p m	210	0.5[3]	*S*	1	0- 1	0	0	0
Fis	D	M	13	1 p m	315	20	*S*	3- 14	9-13	12	2- 4	2
Lon	D		13	1 p m	305	40	*S*+L	2- 10	1-11	6	1- 3	2
Lon	W		13	5 p m	335	40	S+L	1- 10	1-10	6	0- 6	1
Fis	W		14	1 p m	315	50	L+S	1- 20	7-14	9	0- 6	3
Lon	S		14	1 p m	240	30	L+S	3- 23	5-13	10	7-13	7
Fis	D	M	14	5 p m				No record				
Fis	D	M	14	5 p m	255	30	S	2- 14	8-19	13	2-16	10
Fis	S		20	1 p m	290	60	L+*S*	4- 24	10-17	10	0-12	6
Bar	W		35	5 p m	120	60	S	1- 7	3-50	19	3- 7	5
Mor	D	M	39	5 p m	110	20	S	4- 7	28-51	39	0-19	7
Gre	D		43	5 p m	170	20	L+*S*	1- 18	5-15	10	4-20	7

[1]M signifies that the infant micturated during the experiment

[2]Mouthed the nipple for long periods

[3]Made 2 weak sucks only and mouthed nipple most of the time

TABLE 3

INDIVIDUAL MEASURES OF SUCKING AND GRIPPING IN THE INSTANCE OF THE DIFFICULT NIPPLE

Name	Condition of diapers before experiment Dry (D) Wet (W) Soiled (S)	Age in weeks	Feeding hour	Time allowed for sucking (Sec.)	% of time spent in sucking	Short or long sucking periods	Time range of sucking periods (Sec.)	Range of sucking pressure (mm Hg)	Median sucking pressure (mm Hg)	Range of gripping pressure (mm Hg)	Median gripping pressure (mm Hg)
Pow	W	1	1 p m	520	95	L+S	1-94	4-15	10	3- 6	4
Aur	S	7	9 a m	360	70	L+S	1-28	1-12	8	3-11	6
Lan	D M[1]	8	5 p m	390	40	L+S	2-22	1-11	7	0-20	6
Lan	D	9	1 p m	320	60	S	1- 8	4-11	7	0-10	3
Lan	S	10	1 p m	420	50	L+S	1-39	4-12	8	6-11	8
Lan	W	10	9 a m	375	20	L+S	1-23	7-12	11	0-20	10
Fis	W	12	1 p m	400	70	L+S	4-53	5-19	13	3- 4	3
Lon	W	12	1 p m.	300	50	L+S	2-37	1- 8	2	0- 3	3
Fis	D M	13	1 p.m	300	80	L+S	3-16	1-16	12	2- 5	4
Lon	D	13	1 p m	300	80	L+S	1-30	0-12	10	0- 5	1+3
Lon	W	13	5 p m	345	60	L+S	2-30	6-13	9	0- 2	2
Lan	S	13	1 p m	480	50	L+S	1-20	4-24	11	0-21	10
Lan	D	13	5 p m	590	70	L+S	1-75	7-18	11	0-20	18
Fis	W	14	1 p m	330	90	L	1-24	14-20	19	1-30	6
Lon	S	14	1 p m	295	40	L+S	3-37	1-18	12	2- 3	3
Fis	D M	14	5 p m	310	70	L+S	1-21	1-17	14	0- 7	1
Fis	D M	14	5 p m	325	40	L+S	1-23	14-17	14	2-10	5
Fis	S	20	1 p m	465	60	L+S	2-34	10-22	12	2-19	8
Bar	W	35	5 p m	270	40	L+S	2-16	11-36	12+35[2]	0-17	6
Mor	D M	39	5 p m				Gets angry	immediately	and cries		
Gre	D	45	5 p m.	540	20	L+S	1-17	1-14	9	0-22	11

[1]*M* signifies that the infant micturated during the experiment
[2]A 2-pressure level of sucking with no intermediate pressure

TABLE 4

INDIVIDUAL MEASURES OF SUCKING AND GRIPPING IN THE INSTANCE OF THE EASY NIPPLE

Name	Condition of diapers before experiment Dry (D) Wet (W) Soiled (S)		Age in weeks	Feeding hour	Time allowed for sucking (Sec)	% of time spent in sucking	Short or long sucking periods	Time range of sucking periods (Sec)	Range of sucking pressure (mm Hg)	Median sucking pressure (mm Hg)	Range of gripping pressure (mm Hg)	Median gripping pressure (mm Hg)
Pow	W		1	1 p m	375	70	L+S	1- 31	6-15	10	0-20	9
Lan	W	M[1]	9	5 p m	340	80	L	1- 18	3-10	7	0-12	7
Lan	S		13	1 p m	130	100	L	1- 30	11-26	12	5- 7	7
Lan	D		13	5 p m	435	99	L	46-193	12-14	13	11-25	13
Fis	S		20	1 p m	390	90	L	20- 72	11-18	13	7-17	10
Bar	W		35	5 p m	330	70	L+S	1- 36	3-37	19	1- 4	4
Mor	D	M	39	5 p.m.	320	40	L	1- 9	10-41	15+33[2]	0-21	12
Gre	D		45	5 p m	395	80	L+S	1- 71	5-14	8	0-16	6

[1] *M* signifies that the infant micturated during the experiment.

[2] A 2-pressure level of sucking with no intermediate pressure.

TABLE 5

INDIVIDUAL MEASURES OF SUCKING AND GRIPPING IN THE INSTANCE OF BREAST FEEDING

Name	Condition of diapers before experiment Dry (D) Wet (W) Soiled (S)		Age in weeks	Feeding hour	Time allowed for sucking (Sec.)	% of time spent in sucking	Short or long sucking periods	Time range of sucking periods (Sec.)	Range of sucking pressure (mm Hg)	Median sucking pressure (mm Hg)	Range of gripping pressure (mm Hg)	Median gripping pressure (mm Hg)
Obl	W		2	1 p m	230	95	*L*+S	1-177	9-52	15+40[2]	0-18	9
Obl	D		2	5 p m	540	90	*L*+S	5-120	9-80	10+73[2]	0-14	10
Obl	W	M[1]	3	9 a m	900	80	L+S	1- 60	10-40	17+39[2]	5-23	8
Phi	W		4	1 p m	420	95	*L*	4-132	15-73	38	0- 9	7
Lan	W	M	9	5 p m	360 RB[3]	90	L	1- 62	5-30	26	0-19	15
Lan	W	M	9	5 p m	310 LB	70	L	2- 70	13-23	13	0-20	10
Lan	S		10	1 p m	480 RB	100	L	4- 80	8-20	11	12-17	13
Lan	S		10	1 p m	410 LB	90	*L*+S	4-125	13-18	11	0-19	12
Lan	W		10	9 a m	305 LB	80	*L*+S	2- 48	7-27	11	2-14	8
Lan	W		10	9 a m	350 RB	98	*L*	7-105	21-72	37	3-10	8

[1]*M* signifies that the infant micturated during the experiment

[2]A 2-pressure level of sucking with no intermediate pressure

[3]*RB* signifies that the feeding occurred at the right breast, and *LB* signifies that the feeding occurred at the left breast According to the mother's statement, *Lan* prefers the right breast

Tables 2, 3, 4, and 5) The infants and the number of times each served as a subject are as follows:

Infants[4]	No of times used
Pow, bottle baby	1
Obl, breast baby	3
Ani, breast baby	2
Phi, breast baby	1
Lan, breast and bottle baby	8
Fis, bottle baby	7
Lon, bottle baby	5
Bar, bottle baby	1
Mor, bottle baby	1
Gre, bottle baby	1

The customary sanitary precautions were observed with respect to apparatus, nipples, and milk

G Results

Although even a hungry neonate may suck for several minutes at an empty nipple, sucking is primarily a food-getting response This is shown by the fact that unless the activity is eventually rewarded with food, sucking gives way to fretting and crying When the breast or bottle is presented the infant concentrates his energy in consuming the milk. Movements of the head, trunk and legs, clenching of the hands, and clinging to the mother are all parts of the food-getting response If the milk flows easily, body activities are few and mild, if difficulty is experienced in obtaining the milk, they become numerous, vigorous, and are often accompanied by fretting and crying The infant continues to suck milk until he is satiated, falls asleep, or exhausts the supply He stops only to breathe or rest These brief rests with the nipple in the mouth may be the first stage of playing with the nipple As he gets older a time arrives when for short intervals in the feeding period he forsakes sucking to look around or indulge in pseudo-sucking or mouthing

1 *Duration of Sucking Periods* The duration of sucking periods was determined for all types of sucking, but attempts to chart the results met with serious difficulties. In the first place there was a great deal of mouthing and very weak sucking Most mouthing occurred with the lips slightly slitted so that no pressure was registered However, mouthing with lips closed sometimes

[4]The ages of the infants at the times they were experimented upon is indicated in Tables 2, 3, 4, and 5

gave slight depressions in the sucking curve—not unlike weak sucking. In fact, mouthing and weak sucking were not always differentiable There were single and double strong and weak sucks followed by a rest, and long and short sucking periods separated by periods in which sucking movements ceased but negative pressure was maintained on the nipple (rest but not complete rest) There were periods of sporadic strong and weak sucking separated by momentary rests Often a short or long period of sucking deteriorated into very weak sucking and mouthing movements, some of which registered In nearly all cases single sucks occurred which could not be identified definitely as belonging to a series of sucking movements

In the face of these difficulties, it was necessary to set an arbitrary rule for determining the length of a sucking period One suck or a series of sucks in which the successive sucks were not separated at any point by a time interval of one second or more constituted a sucking period Sucks of less than 2 mm. Hg pressure were ignored unless they signaled the start of a sucking period. In Tables 2, 3, 4, and 5, sucking periods were designated as short (S) if they lasted 10 seconds or less, and long (L) if they extended beyond 10 seconds. When both long and short sucking periods occurred during a situation, they were so indicated (L + S).

Tables 2, 3, 4, and 5 contain rather full descriptions of the concurrent sucking and gripping reactions of infants to air sucking and to difficult nipple, easy nipple, and breast feeding Names of infants appear in the first column at the left of the table. The condition of the diapers, dry, wet, or soiled, at the time when they were removed before the feeding period, and whether or not micturition occurred during the course of the experiment, are shown in the second column The age of the infants and time of feeding are indicated in the following two columns Next each of the four different sucking situations, i e , air, difficult nipple, easy nipple and breast, are considered with respect to time (in sec) permitted for sucking, the percentage of this time actually spent in sucking, whether the individual sucking periods are long or short, the range of these periods in seconds, sucking pressure in terms of the range and median, and the range of gripping pressure and the median gripping pressure.

Of the total time allowed for sucking in each of the four nipple situations the amount of time (in %) actually spent in sucking was as follows

Air sucking (21 cases)	40%
Difficult nipple sucking (20 cases)	60%
Easy nipple sucking (8 cases)	80%
Breast sucking (10 cases)	90%

Although the number of seconds an infant actually spent in sucking in each situation was determined, the percentage of time credited to him was the nearest multiple of 10. The only exception to this rule was at percentages above 95 and below 10, in which instances exact measures appeared to carry some significance For example *Lou* at 12 weeks made but two feeble sucks lasting a second at the 1 o'clock feeding when sucking air This represented only ½ of 1 per cent of the total time permitted for air sucking On the other hand, *Lan* at 10 weeks sucked continuously for almost the entire period (or 98 per cent of the time) allowed for sucking at the right breast at the 10 o'clock feeding

Only two infants, one at the breast and one at the easy nipple, sucked continuously throughout a situation A few of them took one or two very brief rests and thus fell slightly below 100 per cent in sucking time Infants usually sucked continuously for a long or short period at the easy nipple or breast, then rested for a short time and repeated this process until they had finished feeding The duration of single sucking periods varied from one second to several minutes

The range for all infants in the four sucking situations was

Air	1-171 sec
Difficult nipple	1- 94 sec
Easy nipple	1-193 sec
Breast	1-480 sec

The range of the medians for the individual infants in each situation was

Air	2- 15 sec
Difficult nipple	1- 26 sec
Easy nipple	1- 54 sec
Breast	3-112 sec

Long sucking periods predominated in easy nipple and breast

feeding, short sucking periods predominated in air sucking, long and short periods were of equal frequency in difficult nipple feeding

2. *Swallowing.* According to Jensen (37) the infant swallows when he has accumulated a certain amount of milk in his mouth Although no swallowing occurs during the first few sucks, after the sucking is well under way a suck is usually followed by a swallow In one instance the ratio of sucking to swallowing is 2 1. Jensen reports that there is no swallowing in air sucking

With older infants, however, the suck-swallow rhythm changes In addition, the swallowing activity[5] frequently occurs with the corners of the mouth slightly ajar so that the movement does not register.[6] On many occasions the lips opened at each swallow At other times they opened only for occasional swallows.

Without unduly stressing the effect of practice on sucking behavior, it can be stated that although there were many instances in which the suck-swallow ratio was 1 1 or 2 1, where nourishment was obtained, there were also many instances wherein the ratio was very complicated On the other hand there were many instances in which two or more successive swallows followed a series of sucks On these occasions there was frequently a definite pause in the sucking activity Sometimes the mouth was slightly parted At other times it was closed and swallowing was recorded as notches on the sucking curve at the 0 pressure level. Double swallowing is not unusual Observation of older infants, 12-40 weeks, reveals that two successive swallows occasionally occur when milk is easily obtained. Another peculiarity is that infants feeding at a suck-swallow ratio of 1 1 will suddenly shift to several sucks per swallow

Present records show that the suck-swallow ratio varies considerably for the easy and difficult nipples and for the breast The number of sucks preceding a swallow at the easy nipple ranged from 1 to 10 with a medium of 4 The number of sucks per swallow at the difficult nipple ranged from 1 to 28 with a median of 6 and at

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[5]An excellent description of the process of swallowing is presented by Gesell and Ilg (26, pp 29-32)

[6]When the lips were dry, observation showed that during swallowing the corners of the mouth were slightly ajar When the lips were wet, movements of the air bubbles in the milk at the corners of the mouth indicated that the lips were separated during swallowing Air bubbles rising in the milk of the bottle during a series of these sucks and swallows furnishes additional proof that air must have entered the mouth

the breast 1 to 22, with a median of 5. *Lau* at 9 weeks revealed a range of 1-14 sucks, median 4, at the left breast, and a range of 1-6 sucks, median 1, at the right breast; which probably indicates that he obtained a smaller amount of milk per suck (due to difficult breast or low milk supply) at the left than at the right breast. *Lau* also showed double and, infrequently, triple swallows at the right breast.

In general it is true that no swallowing occurs during air sucking. However, over a protracted period of air sucking the accumulation of saliva probably necessitates occasional swallowing movements. At least our records reveal a few widely separated swallowing movements. In this connection Preyer (53, p. 258) states that while swallowing is normally associated with sucking, it is not essential to prolonged sucking at the empty nipple. Variations in the pressure of the individual sucks of a sucking series resulted in changes in the suck-swallow ratio. Such changes occurred frequently in difficult sucking. In the easy nipple and breast feeding situations sucking and swallowing generally took place with great regularity and often assumed a definite rhythm. The records show numerous instances of trochaic and dactylic rhythms (see Figures 4*B*, 6*A*, and 7). Rhythms of 4, 5, 6 and 7 sucks to a swallow appeared less frequently.

3. *Sucking Rate.* The rate of sucking varied considerably for the different situations. The number of sucks per minute for all types of sucking ranged from 44 to 208. For the different sucking situations the rates were as follows:

Air	84-208 sucks per minute
Difficult nipple	76-140 sucks per minute
Easy nipple	44-132 sucks per minute
Breast	84-108 sucks per minute

The frequencies were obtained from the first five minutes of sucking. Inasmuch as it was not always possible to find 1-minute periods of continuous sucking, the rate for each sucking situation was obtained by adding the number of sucks which occurred in four widely separated 15-second intervals, each of which was located midway of a sucking period.

Available sucking curves of the neonates used in Jensen's study (37) show that these very young infants sucked air at a rate of more than 100 sucks per minute and milk of a temperature of 40° C. at a rate between 60 to 90 sucks per minute.

In this connection comparison of the sucking curves in feeding at the easy nipple revealed that the sucking rate per minute was,

84 to 100 sucks for prolonged weak sucking
80 to 88 sucks for prolonged strong sucking
96 to 112 sucks for prolonged deep sucking

Baliassnikowa and Model (2) state that all newborn infants do not suck alike They classified their 117 infants as follows. Fail to suck, 12, weak sucking, 21; normal sucking, 74, and active sucking, 10 The normal sucker made 7-13 sucking movements in succession and then paused for a second before repeating this performance The active sucker made more sucking movements before pausing One active sucker made 112 sucking movements in the first minute and continued to feed strongly for 10 minutes during which time he made a total of 580 sucking movements When the newborn infant was placed at the mother's breast he made searching movements with the head and opened his mouth as if seeking the mother's nipple During sucking the pulse increased as much as 16 to 30 beats per minute and appeared more rhythmical than usual Respiration also accelerated and became more rhythmical, although its regularity was interrupted occasionally by long sighs. Body temperature, determined anally, fell slightly during the feeding period

From the point of view of the physiology of fatigue, sucking movements are probably essential to proper feeding of the young infant. He controls the amount of milk in the mouth by regulating the strength of the sucking movements For each such movement there is a phase of tension—fatigue-producing phase—in which the infant sucks, and a phase of relaxation (33, p 28)—recuperation—during which he rests and frequently swallows Thus each suck cycle is a physiological process in which energy is not only being consumed, but also restored. Sucking of this type is superior to sucking in which negative pressure is maintained without sucking movements Now it is quite probable that infants at times obtain milk by the latter method When an infant apparently resting maintains a sucking pressure greater than that required to obtain milk through the nipple, there is reason to believe that he is obtaining milk at this time even though he is making no sucking movements Instances of strong sucking pressure without sucking movements occur in breast

and easy nipple feeding (see Figure 7) [7] In this connection some of Jensen's curves show this peculiarity

The rate of sucking probably depends in part on the frequency at which swallowing occurs and therefore on the ease with which milk is obtained In the case of air sucking the sucking rate is high because the swallowing activity which probably retards the sucking activity usually is absent When milk is obtained with difficulty, several sucks are required to get as much milk as is obtained by a single suck at an easy nipple Hence, if swallowing depends on the amount of milk in the mouth, fewer swallows per minute will occur in difficult sucking than in easy sucking. Thus the retarding influence of swallowing will only slightly affect difficult sucking Another reason advanced for the high sucking rate in difficult sucking is that the insufficient flow of milk causes the infant to "speed up" his sucking

4 *Types of Sucking* Sucking pressure was usually stronger at the start than at the end of the feeding period In 10 tests of sucking pressure with the easy nipple during which the milk supply was absorbed, there were eight instances in which sucking pressure decreased during feeding and two instances in which there was no appreciable fall in pressure In the latter instances the infants continued to suck air after the milk supply was exhausted and in one of these instances the infant cried and sucked alternately until he was removed If it be true that the normal infant consumes most of the milk within the first five minutes of the feeding period (3), it can be easily understood that sucking pressure would be strong during the first stages of feeding

There were marked individual differences in sucking A study of the strength and character of sucking, based on observation of the infants and examination of the kymograph records, disclosed the following types of sucking

a Indolent weak[8] sucking for short periods separated by long periods of quiet, looking around, or playing with the nipple Infants

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[7]Neither slow nor rapid movements of the pressure tube, nor shifting its location, within the mouth of the breast infant produced any changes in sucking pressure at these times The tube had to be pulled out of the mouth to bring about such change

[8]The records permitted classification of sucking according to negative pressure as follows Weak sucking, below 10 mm Hg, strong sucking, 10-30 mm Hg, deep sucking, above 30 mm Hg

of this type have been seen to spend more than 40 minutes without completely emptying the bottle

b Steady weak sucking of less than 10 mm. Hg pressure during which the pressure returns to 0 after each suck

c Alternations of strong and weak sucking series or variations in strength of successive sucks Although the individual sucks of a series are seldom of exactly equal pressure, the difference in pressure is sometimes so slight that the series may resemble a pressure plateau. Frequently a succession of plateaus of different heights appear in a short session of feeding. Variations in pressure of successive sucking movements sometimes occur. Occasionally these movements display a rhythmic quality comparable with a metrical unit of verse. The rhythm sometimes continues for several seconds (see Figures 4*B* and 7)

d. Strong regular sucking of 10-30 mm. Hg pressure with only an occasional short rest. Pressure usually returns to 0 after each suck

e. Strong regular or irregular sucking of 10-30 mm Hg pressure for 30 seconds or longer followed by a surge of deep sucking of 30-80 mm. Hg pressure and ending with strong sucking

f. Deep sucking First there is a sharp increase in sucking pressure during the first few sucks until a very high pressure level (30-73 mm Hg) is attained This level may be maintained for a long period. This plateau may be followed by a sudden outburst of even stronger sucking, by weaker sucking, by cessation of sucking during which the pressure suffers little or no change, or by sudden drop in sucking pressure to 0 with the last few sucks of the series

g. Deep voracious sucking interrupted by frequent rest intervals (see Figure 11), followed finally by strong steady sucking

Deep sucking occurred frequently at the breast (see Table 5). However, there were two instances of such sucking at the easy nipple and one at the dry nipple.

In breast feeding, sucking pressure during the first few sucks generally mounted quickly to a level of 18-73 mm Hg When this pressure level was reached several sucks in rapid succession were made before swallowing occurred. Swallowing frequently required two or 3 seconds before sucking was resumed.

Combinations of strong and deep sucking appeared at easy nipple,

difficult nipple, and breast feedings (see Figure 6*B*) The records (see Tables 3, 4 and 5) show two distinct levels of sucking pressure in one case each of easy and difficult sucking and in three instances of breast feeding In these five instances the infants shifted suddenly from one level (10-17 mm Hg) to another (33-73 mm Hg) with no intermediate levels, hence their records show two median pressures to distinguish this type of sucking from sucking in which changes from one level to another were accomplished gradually in a sucking series In this connection Creamer (16) reported pressures greater than any listed in this study.

h. Pseudo-sucking Inasmuch as sucking connotes suction—a drawing into the mouth—no better term for this type of activity suggests itself The infant carries on movements with the mouth which have all the appearances of the sucking activity The mouth action may be weak or vigorous In either case close observation reveals that the corners of the mouth are slightly open so that no sucking pressure is registered.

i. Mouthing, which includes lipping, tonguing, and gumming the nipple When infants ceased sucking for a time but retained the nipple in the mouth they frequently resorted to mouthing the nipple—an activity in which the lips and tongue engaged in licking movements At times they gummed the nipple by successive upward thrusts of the lower jaw so that the nipple was depressed between the gums with enough force to register on the sucking record At other times they thumped the nipple vigorously with the tongue, rolled it about in the mouth or held it quietly until sucking was resumed. All of these responses may be regarded as purely playful activities. In this experiment licking, gumming, thumping and rolling the nipple occurred only for the older infants at the bottle nipple. None of the breast babies or young infants (under six weeks), exhibited these reactions, although some of them were reported as thumb or finger suckers.

Psychoanalysts classify pseudo-sucking, mouthing, and probably weak sucking, as pleasure sucking—activity designed not for food-getting but for the purpose of producing pleasure by feeling or manipulating the pleasure-giving object The mouth in this case is said to serve as an erogenous (pleasure-producing) zone Infants early in life suck the thumb, fingers, and objects within reach of the mouth, but whether or not this activity is an expression of the

sexual instinct is difficult of proof. It is interesting that this study fails to reveal any evidences of false sucking or mouthing at the breast or bottle during the first five weeks as long as food is available.

Types of sucking observed in these infants at times other than feeding include:

(*a*) Sucking movements of the lips without external stimulation of the mouth. These movements occur during sleep and after the feeding period.

Babies often make sucking movements with the mouth during sleep. One infant, *Obl*, who fell asleep at the close of the feeding period retained the nipple in the mouth and continued the sucking movements. These movements were executed vigorously enough to register a pressure of 7 mm. Hg (see Figure 9). Removal of the nipple was accomplished without disturbance to the sleeping infant but the sucking movements ceased immediately.

(*b*) Thumb, finger, and fist sucking. During the waking period this type of sucking is often carried on in lively fashion. During sleep the child sucks weakly and intermittently or merely keeps the hand at the mouth.

(*c*) Sucking at clothing, toys, etc., during the waking hours.

5. *Sucking Pressure.* In order to compare sucking pressures in four nipple situations, sucking pressures for each individual in each experiment were established by determining the median pressure for each series of sucks in a situation and finding the median value of these medians. With this method of computation the range of the medians, and the medians of all the median values for sucking at the different nipples, were as follows:

	Range of the medians	Median of the medians
Air sucking	0-39 mm. Hg	8 mm. Hg
Difficult nipple sucking	2-19 mm. Hg	11 mm. Hg
Easy nipple sucking	7-19 mm. Hg	12.5 mm. Hg
Breast sucking	10-38 mm. Hg	14 mm. Hg

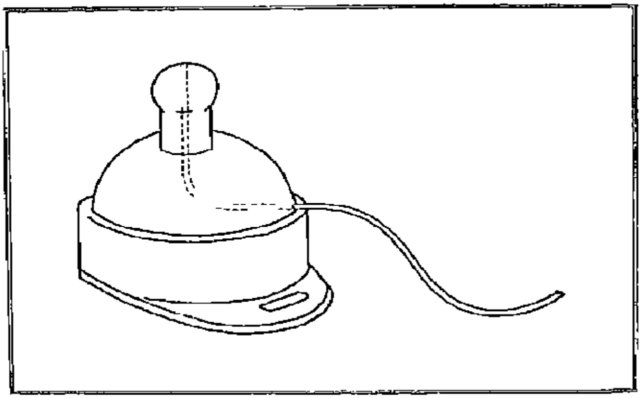
Median pressure values of deep sucking in the five cases wherein two pressure levels appeared (see Tables 3, 4 and 5) were not included in the computations. Inasmuch as three of these extremely high pressure medians occurred in breast feeding, their inclusion would have greatly increased the median pressure value for this type of feeding.

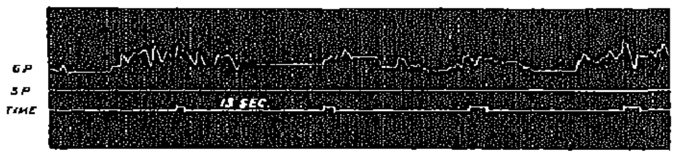
Extreme sucking pressures ranged from 0 to 51 mm. Hg at the dry (air) nipple, from 0 to 36 mm. Hg at the difficult nipple, from 3 to 41 mm. Hg at the easy nipple, and from 5 to 80 mm. Hg at the breast.

Median sucking pressures were easily determined in most cases. The pressure under which sucking in the different conditions of the experiment occurred was a matter of individual differences of the infants as well as a matter of the pressure required to obtain milk through the nipples. Each infant apparently has a preferential sucking pressure level—a predilection for putting a certain amount of energy into his sucking. Barth's observations (3) confirm this point of view. However, there are infants who under identical conditions manifest two levels of sucking pressure, a strong and a deep level, as Tables 3, 4, and 5 indicate. They sometimes appear within a single series of sucks without any interruption in the feeding process. At other times the infant after a series of strong sucks suddenly attacks the milk supply with great vigor.

The medians of the individual median sucking pressures, shown above, indicate that infants sucked with greater force at the breast than at the bottle nipples. Similarly they registered greater pressure at the easy nipple than at the difficult nipple. Air sucking gave the lowest median pressure. The range of the measures is greatest for air sucking and least for easy nipple sucking. In air sucking 0 pressures occur because infants after several short unsuccessful attempts to procure milk refuse to suck and resort to playing with the nipple. On the other hand, high pressures occur through renewed efforts to obtain nourishment by greater force when the customary pressure which is usually successful in delivering milk fails in its mission (see *Mor*, Table 2). In the latter case crying usually follows sucking.

The first few sucks of a sucking period usually increase in pressure. In weak sucking the general level of sucking pressures may be attained almost immediately; in a few instances the first few sucks are stronger than the succeeding ones. In deep sucking the increase in sucking pressure is extremely rapid, sometimes as great as 10-25 mm. Hg between successive sucks (see Figure 11). Although most high pressures usually occurred within the first few minutes, frequent jumps from high to low pressures appeared throughout the feeding period.

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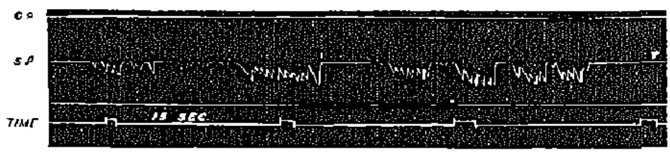
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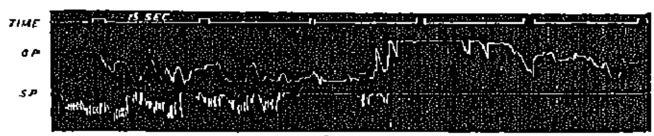
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FIGURE 1

THE NIPPLE

The small rubber tube (outside diameter, 3mm.) communicates with the mercury manometer

FIGURE 2

INFANT *Fis*, 12 WEEKS

The nature of gripping pressure (GP) preceding the feeding period. Infant is restless The infant is not sucking, hence sucking pressure (SP) is 0

FIGURE 3

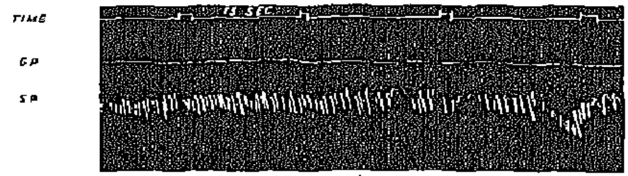
INFANT *Fis*, 14 WEEKS

Sucking at the dry nipple followed by tumescence (T) Gripping pressure (GP) is strong and constant This is one of the few records in which gripping pressure does not fluctuate during the onset of T Sucking pressure (SP) is fairly strong

FIGURE 4

(A) INFANT *Lau*, 13 WEEKS

Sucking at the difficult nipple Sucking becomes irregular and finally ceases as tumescence (T) sets in Note the fluctuations in gripping pressure (GP) (B) With the presentation of the easy nipple sucking becomes smooth and rhythmic, gripping pressure (GP) becomes steady, and detumescence (D) takes place. Sucking pressure (SP) is strong and fairly constant The shifting of the time marker is due to the marked increase in gripping pressure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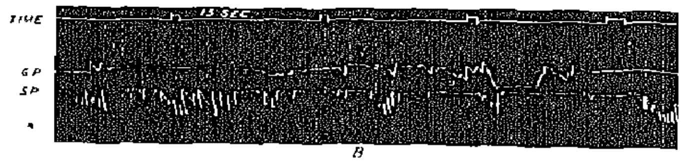
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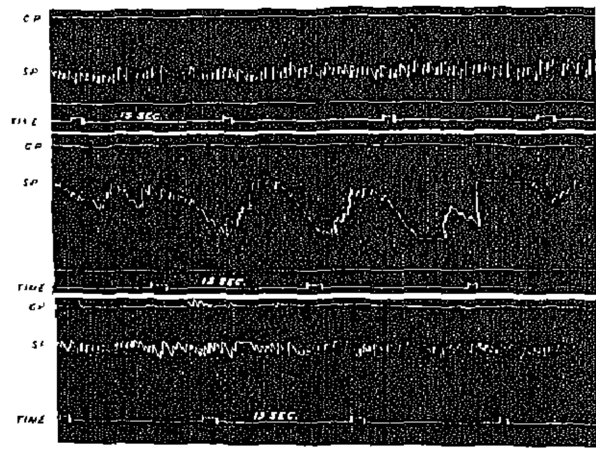
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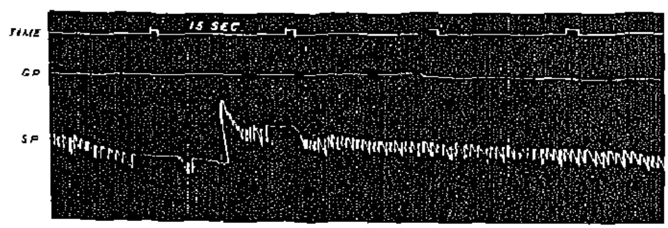
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FIGURE 5

INFANT, *Lan*, 13 WEEKS

Sucking at (A) easy nipple and (B) difficult nipple Note that gripping pressure (GP) is steady during easy sucking and fluctuates during the difficult sucking Sucking pressure (SP) is more constant at the easy nipple than at the difficult nipple

FIGURE 6

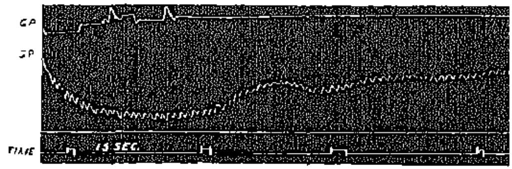
INFANT *Lan*, 9 WEEKS

Sucking at (A) left breast, (B) right breast, and (C) bottle—easy nipple Note that gripping pressure (GP) is very steady at A and B and only slightly fluctuating at C Sucking pressure (SP) is fairly constant at the left breast, very strong but irregular at the right breast, and generally weak and somewhat irregular at the bottle

FIGURE 7

INFANT *Obl*, 3 WEEKS, SUCKING AT BREAST

He maintains strong sucking pressure (SP) in resting and later releases the pressure Strong, rhythmic sucking is exhibited during the remainder of the period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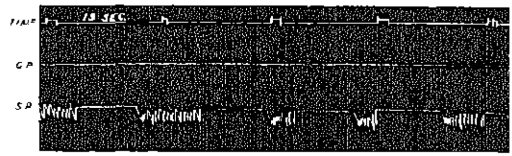
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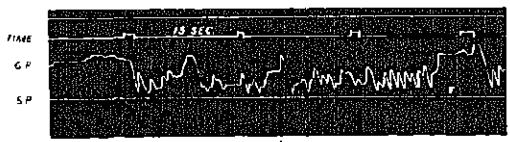
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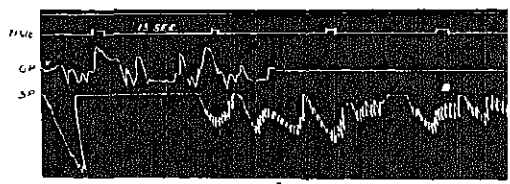
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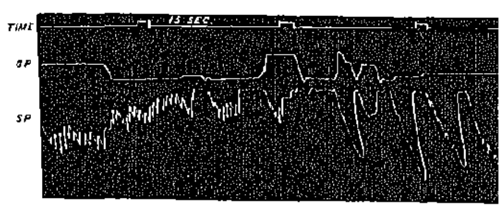
TIME
15 SEC.
GP
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FIGURE 8

INFANT *Phi*, 4 WEEKS

Continuous sucking at breast Gripping pressure (GP) increases irregularly with sucking pressure (SP) and finally becomes steady

FIGURE 9

INFANT *Obl*, 3 WEEKS

Near the end of the feeding period he sleeps but continues sucking at regular intervals When the breast is removed, *Obl* continues to sleep but the sucking movements cease.

FIGURE 10

INFANT *Obl*, 3 WEEKS

When the breast is removed (A) *Obl* cries and kicks. T finally occurs When the breast is restored (B), he makes several strong sucks but his excitement is so great that 15 seconds elapse before he finally settles down to steady sucking Note that gripping pressure (GP) becomes constant only after several seconds of continued sucking and that detumescence sets in at D Sucking pressure (SP) varies considerably

FIGURE 11

INFANT *Obl*, 3 WEEKS

This record shows that occasionally a sudden burst of strong sucking is accompanied by a corresponding abrupt increase in gripping pressure (GP)

6. *Gripping Pressure and Body Tension during the Feeding Period* It was previously stated that gripping pressure was recorded concurrently with sucking pressure in order to obtain evidence of the state of muscular tension before, during and after the feeding period and also at interruptions in the feeding activity. It appears that in early infancy the state of tension of the finger flexors, recorded here by gripping pressure, is indicative of the state of tension of the skeletal musculature (28, pp 441-443) When an infant closes lightly on objects, very little tension is manifested by muscles of other parts of the body, when he grips tightly, the strength of the grip is reflected by a general increase in tension by flexor muscles of the entire arm in a distal-proximal direction Even remote body parts, such as the legs, reflect the increase in tension by the finger flexors Rapid alterations in tension of the general body musculature which occur during emotional upsets are clearly shown by rapid fluctuations of gripping pressure while periods of calm are accompanied by steady gripping pressure.

Present records show that during periods of composure in feeding, under conditions of steady sucking, strong or weak, infants always maintained a quiet tense posture during which only slow movements occurred. This posture was reflected by steady gripping pressure (see Figures 6, 7, and 8). Periods of disturbance in the feeding period were accompanied by rapid alterations in tension of body musculature, which were clearly indicated by rapid fluctuations of gripping pressure (see Figures 4*A*, 5*B*, and 10)

This tendency of the skeletal musculature to tense coincidentally with contraction of the flexor tendons of the hand was checked by frequent feeling of the infant's arms, chest, neck, abdomen, and legs, under conditions wherein grasping varied from unusually strong to weak. Experiments which are designed to show this "spread" of tension are now in progress

In early infancy, sucking pressure and gripping pressure may both be regarded as measures of the relative strength of the hunger motivation. When the concurrent records of sucking and gripping in a given situation were viewed with respect to the strength, variability, steadiness and duration of these activities, the correspondence between them was exceedingly close.

The continuous record of the spontaneous sucking and gripping responses during the feeding period reveals in general a gradual de-

crease in the strength of both responses. Just before the breast or bottle is presented to the hungry infant, gripping pressure is unusually strong but extremely fluctuating.[9] When milk is easily obtained at breast or bottle, sucking pressure soon attains its maximum strength and remains at or near this point for some time. The strong and somewhat variable gripping pressure which accompanies the first few sucks quickly assumes a strong and steady trend as the sucking becomes smooth and regular. Fast sucking infants, or those who finish feeding within 6 to 8 minutes, sometimes maintain a strong sucking pressure throughout the feeding period, stopping only for breathing or for readjusting the mouth to the nipple. In the latter case each outburst of renewed sucking is usually preceded or accompanied by a momentary increase in gripping pressure.

Responses to feeding from the difficult nipple fall into two categories. Some infants sucked and gripped strongly and steadily in much the same manner in which they reacted to easy feeding. Feeding, of course, was slower and was characterized by periods of restlessness (see Figure 5*B*). Rest intervals were of frequent occurrence, particularly toward the end of the feeding period. Each renewal of feeding was usually accompanied by a sudden increase in sucking and gripping pressure. On the other hand, most infants after a short interval of strong steady sucking and gripping immediately manifested restlessness in the feeding situation. Sucking became sporadic and finally ceased. Rapid and marked fluctuations in muscular tension occurred, which were indicated by the pressure curve. The restlessness usually increased and ended in rather violent behavior. The activity took the form of stiffening, twisting, rolling, arching, shaking the head, throwing the arms, kicking, fretting, and strident crying. In most cases after quieting down they re-

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[9]Tolerance of the pre-feeding period varied considerably. In most cases the infants, particularly the breast infants, displayed great excitement or restlessness (see Figures 4 and 10). Vigorous body movements, interrupted by periods of marked isometric tension, were attended by crying and body quiver. When the bottle was presented some infants did not, probably could not, at once adjust themselves to the feeding situation. Sucking was sporadic, irregular in time and strength, while gripping pressure fluctuated considerably (see Figure 10*B*). At the end of the feeding period satiated infants lay relaxed or slept and maintained little or no gripping pressure (27, pp. 419-424).

newed their sucking for one or more brief intervals On two occasions an infant in apparent contentment returned to sucking at a pressure far below that required for obtaining milk through the nipple Sucking of this type may be regarded as a form of playful activity, although psychoanalysts would probably classify it as "pleasure sucking." Muscular tension as a rule was greater during sucking at the difficult nipple than during sucking at the easy nipple

Infants' sucking and gripping responses in the air sucking situation followed much the same course as their responses to the difficult nipple Some infants discontinued sucking at once, struggled violently and cried loudly; others fretted, while one infant lay undisturbed after expelling the nipple. A few infants held the capsule weakly but steadily as they sucked intermittently at the nipple and then resorted to mouthing it or holding it quietly between the lips (see Figure 3). One infant sucked and gripped strongly and steadily for nine minutes without resting in the air sucking situation.

Withholding and withdrawing the breast or easy nipple from infants usually signaled the start of crying and violent physical demonstrations. The curve of gripping pressure during these emotional disturbances followed a very erratic course (see figure 10*A*) Strongest and weakest pressures in quick succession were recorded on these occasions. The curve is a very good indication of the extreme and abrupt transformations in tension occurring in the skeletal musculature.

A definite relationship between sucking pressure and gripping pressure is further shown by the following facts. (*a*) In 27 of the 29 sucking situations all long series of sucking movements (20 or more sucks) of uniform pressure were attended by steady gripping pressure (see Figures 7 and 8). In the other two situations there were fewer than 20 sucks in any series (*b*) In 11 of 24 cases sudden outbursts of strong sucking were anticipated by an increase in gripping pressure (see Figures 4*B* and 10*B*); in 7 cases gripping pressure increased simultaneously with increase in sucking pressure (see Figures 8 and 11), in 5 cases gripping pressure remained steady and unchanged, and in 1 case it fell to a lower level (*c*) Gradual increase in sucking pressure was usually accompanied by steady gripping pressure (see Figure 7). In 19 of 28 such cases, gripping pressure remained constant, in 6 instances there was a gradual increase, and in 3 instances slight irregularities accompanied a slight

ise of gripping pressure (*d*) A series of sucking movements in ı the pressure of the individual sucks varied greatly, was led by fluctuating gripping pressure in 9 of 21 instances, by iate steady and fluctuating gripping pressure in 5 instances, y steady gripping pressure in 7 instances. (*e*) Rapid fluctua-in gripping pressure always accompanied fretting and crying Figure 10*A*) (*f*) The records also show that great fluctua-in gripping pressure occurred during delay in feeding (see e 2), at withdrawal of the nipple (see Figure 10*A*), during ılar sucking accompanied by fretting (see Figure 5*B*), and g sucking at the difficult nipple Slight fluctuations usually red during deep irregular sucking and after a long sucking l Individual differences in gripping pressure appeared. The ls of *Lou,* who was not as sturdy as the other infants and was disturbed by hampering situations, show only slight fluctuations pping pressure at any time. On the other hand the records of who reacted violently to delay in feeding, withdrawal of the , etc , invariably show great fluctuations in gripping pressure servations of the behavior of infants in the experimental ion indicate that increases and decreases in strength of sucking ments are accompanied by corresponding increases and decreases dominal tension A series of sucking movements is usually pated by tension of the abdominal walls A long series of ıg movements or an increase in their strength apparently is ded by contraction of the abdominal walls and a reduction e magnitude of abdominal respiration [10]

was expected that muscular tension, so far as it is indicated ipping pressure, would be greater during strong sucking than g weak sucking, it was expected that due to fatigue and gradual tion of the hunger motivation as infants approached the point tiation, tension would be greater at the beginning than at the ıf the feeding period. The results confirm both of these predic-

Changes in tension during sucking which gave no return in shment, and during periods in which the food was withheld, also expected The nature of these changes is now a matter cord

ipping pressure in Tables 2, 3, 4, 5, and 6 refers to pressure

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[10]search on this phase of the problem is now in progress.

TABLE 6

COMPARISON OF SUCKING AND GRIPPING RECORDS FOR THE FOUR SUCKING SITUATIONS

Situations	% time sucking	Time range of single sucking series—in seconds	Sucking pressure (mm Hg)		Gripping pressure (mm Hg)	
			Range	Median	Range	Median
Air	40	1-171	0-51	8	0-20	4
Difficult nipple	60	1- 94	0-36	11	0-30	5.5
Easy nipple	80	1-193	3-41	12.5	0-25	8
Breast	90	1-480	5-73	31[11]	0-23	10

exerted only at the time the infant is sucking. Pressure during periods of withholding the nipple or withdrawing it from the mouth is not shown Table 6 shows that the range of gripping pressure during air sucking was 0 to 20 mm Hg The median of the individual median pressures was 4 mm Hg The range of gripping pressure was 0 to 30 mm. Hg for difficult sucking, 0 to 25 mm Hg for easy sucking and 0 to 23 mm Hg for breast sucking The medians of the individual median pressures for each of these three sucking situations were 5.5, 8, and 10 mm. Hg respectively

The measures in Table 6 indicate that breast feeding leads all other types of sucking with respect to per cent of time actually spent in sucking, length of individual sucking series, sucking pressure, and gripping pressure Easy sucking, difficult sucking, and air sucking follow in order Exceptions to this order occur twice in the air sucking situation and once in the difficult nipple situation (see Tables 2 and 3). Were it not for *Arr* at three weeks who on one occasion sucked air contentedly for 171 seconds without a pause, the time range for a single air-sucking series would be 1-36 seconds Likewise, the range for air sucking pressure would be 0-30 mm Hg, were it not for the impetuous sucking of *Mor* at 39 weeks. (Nurses credit *Mor* with a bad temper) A particularly strong display of gripping pressure by *Fis* at 14 weeks during sucking at the difficult nipple elevated gripping pressure above the 22 mm Hg mark for this type of sucking. The sucking and gripping results probably signify that the preferential order of feeding is breast, easy nipple, difficult nipple, and air

[11]Where two pressure levels occurred, the stronger pressure was used in computing this median, because in all cases the stronger pressure predominated

It is apparent from Tables 2, 3, 4, and 5 that there is little correspondence between sucking and gripping pressures from infant to infant Age and individual differences probably outweigh the factors which make for positive correlation between these measures. For example, if two infants, one of 6 weeks and another of 20 weeks, suck milk with the same amount of pressure, it is conceivable that maintenance of this pressure exacts a greater toll (tension) from the musculature of the younger infant than from the musculature of the older infant.

Significance must be attached to the fact that strong sucking was attended by strong gripping, and weak sucking by weak gripping The gradual increase in sucking pressure from air sucking to difficult sucking, difficult sucking to easy sucking, and easy sucking to breast sucking was paralleled by a corresponding increase in gripping pressure The increase in both sucking and gripping pressure is probably due to an increase in motivation Breast milk is more effective than bottle milk or air, and milk which is easily obtained is more effective than milk which is obtained only with difficulty, as an incentive to sucking and gripping.

7 *Penial Tumescence* There were 60 instances in which penial tumescence (T) of varying degrees appeared (see Table 7) [12] In some cases the phenomenon occurred as frequently as three or four times in a feeding period It is, of course, difficult to give detailed accounts of all the situations under which T took place However, there were eight type situations in which the phenomenon was observed The frequency of each of these situations and the number of T's occurring in each situation follow

Situation	Frequency of situation	No of T's
Infant carried or held by nurse	29	3
Two-minute delay in feeding, gripping pressure only	29	5
Breast removed	15	10
Easy nipple removed	3	1
Sucking at difficult nipple	29	24
Difficult nipple removed	29	1
Sucking at empty (air) nipple	39	13
Empty nipple removed	39	3

[12]The reason for using only boy infants as subjects for this investigation is now apparent Although both girls and boys were used in the preliminary work the frequent occurrence of penial tumescence accounts for the change in the selection of subjects

TABLE 7

CONDITIONS INDICATIVE OF BODY TENSION AT THE ONSET AND DECLINE OF TUMESCENCE

No. of T's observed	Age range of infants in weeks	Body activity at onset of T (56 records available)	Gripping pressure at onset of T (57 records available)	Body activity at decline of T (53 records available)	Gripping Pressure at decline of T (47 records available)
60	1-43	Vigorous body movements (31) Slow body movements with muscles tense (9) Trunk and legs stiffly extended (8) Alternate tensing and relaxing musculature during intermittent sucking (4) Sharp flexion of legs above abdomen and chest (4)	Fluctuating (46) Steady (9) Alternately steady and fluctuating (2)	Body relaxed, infant quiet or quieting (18) Muscles tense, infant quiet or quieting (27) Tense and restless (2) Alternately tense and restless (1) Quiet, alternately tense and relaxed (5)	Steady and constant (37) Slow fluctuations (4) Fluctuating, followed by steady pressure (3) Steady decrease in pressure (2) Alternately steady and fluctuating (1)

r occurred frequently during sucking at the difficult nipple and oty nipple and at removal of the breast On the other hand T er occurred during sucking at the breast or easy nipple There , one instance of T after removal of the easy nipple before the icult nipple could be brought into use Of the 13 T's which urred during air sucking 4 were exhibited by *Fis* at 11 weeks 1 single feeding period The remaining 9 T's appeared singly in erent situations Of the 24 T's recorded during sucking at the icult nipple, 4 occurred in a single feeding period (*Lan*, 13 eks), 3 in another, and 2 in each of 2 other feeding periods. T) appeared two and three times during a single feeding at removal the breast

The following paragraph gives a brief description of the overt avior of *Fis* at onset of T during sucking at the difficult nipple.

> As the infant begins to make strong and rhythmic sucking movements the legs contract stiffly so that the knees are raised high over the abdomen with the toes sharply flexed The hands are fisted near the shoulders The scrotum tightens and the testicles retract toward the inguinal rings The infant now gets restless, sucking becomes arhythmic, and postural orientation toward the source of food—a sort of encircling movement—becomes marked The infant rotates slightly toward the right and brings the knees down against the chest as fretting, crying and T occur coincidentally

1 the other occasions with this infant rigid extension of the body d arching of the back accompanied the onset of T

The conditions under which T appeared and disappeared in each uation are presented in Table 7. The actual sucking situations the onset of T and the frequency of its appearance in each uation were.

Strong sucking at bottle	17
Sucking and mouthing at bottle	11
Bottle removed or withheld	10
Breast removed or withheld	10
Mixed strong and weak sucking at bottle	7
Delay in feeding (held by nurse)	3
Weak sucking at bottle	2

If these situations are examined closely it will be found that T curred 23 times at withholding of breast or bottle, 13 times in the

air sucking situation, and 24 times in the difficult nipple situation In other words, in 36 instances infants obtained no milk, whereas in 24 instances they obtained only a limited amount of milk with great expenditure of energy.

Sucking pressure during the onset of T varied greatly from infant to infant.[18] The range of sucking pressure for all infants was 0-51 mm. Hg. The median variation was 5 mm. Hg In 11 cases only was sucking pressure steady.

In general, strong sustained or intermittent body tension due to isotonic or isometric muscular contraction preceded and accompanied the onset of T. The frequency of straining movements, great restlessness, fretting and crying at this time are indicative of the state of muscular tension. In 31 cases the activity consisted of vigorous trunk, arm, and leg movements In 9 cases infants with muscles tense moved trunk, arms, and legs slowly as they strained at the bottle. In 8 cases they held the trunk and legs extended stiffly In 4 cases infants alternately tensed and relaxed their musculature during periods of intermittent sucking, and in 4 cases they flexed the legs sharply above the chest so that the knees were close to the bottle. In 22 cases infants were fretting and crying, in 7 cases they were only fretting, in 16 cases infants moved restlessly, and in 13 cases they were quiet but tense. Great fluctuations in gripping pressure usually accompanied the onset of T In all there were 46 instances of fluctuating gripping pressure, 2 instances of alternate steady and fluctuating pressure and 9 instances of steady pressure Of these 9, pressure remained unchanged in 3 instances, increased gradually in 4 instances, and fell slowly in 2 instances The range of the fluctuations was from 0 to 22 mm Hg. The median variation of all gripping pressures was 11 5 mm Hg

The feeding situations under which detumescence (D) took place were as follows.

Sucking or mouthing empty nipple or resting with it in the mouth	13
Sucking at easy nipple including 3 cases in which sucking records were not taken	15

[18]Sucking pressure usually varied during T and D. However, some infants maintained a constant pressure on the nipple as long as they continued to suck

Continued sucking at difficult nipple following T at this nipple	5
Mouthing or resting with difficult nipple in mouth following T at this nipple	5
Sucking at breast following its withdrawal from infant	9
Sucking at his own bottle (regular nursery nipple)	7
Resting after prolonged sucking at difficult nipple	1
Lying in crib awaiting feeding	1
Taken away and fed in nursery	2
Removal of empty nipple or difficult nipple	2

There were 46 instances in which D occurred during sucking at the experimental nipples The types of sucking and frequency of each type were as follows strong, steady sucking, 13; steady sucking varying in strength but always strong, 8, mixed sucking and mouthing, 6, mixed strong and weak sucking, 5; resting and mouthing, 4; resting, 3, mouthing, 2, weak sucking, 4, and resting and smiling, 1 Sucking pressure for all cases ranged from 0 to 72 mm. Hg with a median variation of 2 5 mm Hg There were no changes in sucking pressure in 19 cases.

Conditions indicating the physical and emotional state of infants were relaxed and quiet or quieting, 18, tense but quiet or quieting, 27, tense and restless, 2, alternately tense and restless, 1, alternately tense but quiet, 5 Tension at this time was of the sort usually associated with the sucking activity. The greater this tension, the slower the D There was no fretting or crying during D. Of the 47 available records there were 37 cases in which gripping pressure was maintained steadily at one level. There were 4 cases of slow fluctuations of gripping pressure, 3 cases in which fluctuating pressure was followed by steady pressure, 2 cases of steady decrease in pressure and 1 case of mixed steady and fluctuating pressure The range of gripping pressure for all cases was 0 to 30 mm Hg with a median variation of 2 mm Hg, which was 9 5 mm. Hg less than the median variation during T

Table 8 summarizes the actual feeding conditions attending the onset and disappearance of T in all 60 cases For example, the first cell of the table shows that 10 instances of T occurred during sucking at the difficult nipple and that T disappeared in these instances during sucking at the easy nipple

TABLE 8
FEEDING CONDITIONS UNDER WHICH T DISAPPEARED

Feeding conditions under which T occurred	Sucking at easy nipple	Breast restored	Weak sucking and mouthing	Resting and mouthing	Sucking air	Resting	Sucking at own bottle	Nipple removed	Sucking at difficult nipple	Weak sucking	Infant removed
Sucking at difficult nipple	10		2	4	2	2	1	1	2		
Sucking air	1		3	1	1	2	2	1		1	1
Withholding breast	1	9									
Delayed feeding. Gripping pressure only	1				1		3				
Delayed feeding Held by nurse						1	1				1
Air sucking: Nipple removed	1			1	1						
Easy nipple. Removed	1										
Difficult nipple withheld									1		

Comparison of gripping pressures at the onset and at the decline of T was made in the 45 instances wherein measures at these points were available In 24 instances the general level of gripping pressure was higher at the onset of T, in 18 instances the pressure level was higher at the decline and in 3 instances pressure was the same at both points The median gripping pressure for all cases was 8 5 mm. Hg (m. v of 2 4 mm Hg) at the onset of T and 7 0 mm Hg (m. v. of 3.9 mm Hg) at D, whereas the average pressures were 7 3 and 8.1 mm. Hg respectively Extremes in gripping pressure usually occur during the onset of T Pressure reached its highest point at this time in 31 cases and its lowest point in 26 cases In 19 cases highest and lowest pressures were both registered at this time. Gripping pressure attained its greatest height during the abatement of T on 8 occasions and its lowest point also on 8 occasions. Top pressures for onset and abatement of T were equal in 6 instances and lowest pressures equal in 11 cases Hence, whereas the general level of gripping pressure was higher at the onset of T than at D in only about one-half the cases, extreme fluctuations in pressure occurred with much greater frequency at the onset of T than at its decline

The high gripping pressure level during the decline of T is explainable as part of the general *increase in muscular tension* as the infant resumes sucking when the withheld breast or bottle is restored to him.

The significance of gripping reactions during T and abatement of T lies not so much in the strength of the responses as in their character[14] Gripping responses during T take on an explosive quality. Relaxation and strong contraction of the finger flexors follow each other in rapid succession as the restless excited infant alternately tenses and relaxes his body Gripping responses during D acquire steadiness The infant may suck strongly or weakly at the nipple, but his body soon assumes a more or less constant tension, interrupted only by breathing or change of posture, and the fingers flex with steady pressure on the capsule, as he settles down to feeding[15]

In passing, there was considerable variation in amount of turgidity of the penis, in speed of engorgement and disgorgement, and in duration of T for the several infants and for the individual infant on different occasions *Fis, Lan, Obl* and *Gre* usually attained maximum turgidity quickly, D occurred slowly in the case of *Fis* and quickly for *Lan, Obl,* and *Gre.* T took place slowly for *Lon,* never reached maximum turgidity and disappeared rapidly

Attempts to record the duration of T met with only partial success It was often difficult to decide just when T began and when it terminated In 29 instances, however, fairly close estimates in terms of multiples of 5 seconds were made of the duration of the phenomenon In 20 of these instances infants were sucking at the difficult nipple, in 2 instances they were sucking air and in 7 instances the breast was removed The median duration for all 29 cases was 80 seconds, the average duration 111 seconds, and the range 15 to 440 seconds. It might be added that the onset of T occurs very rapidly in some instances (about 10 seconds) and very slowly in others.

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[14]It can readily be seen that the conditions under which the experiment was conducted produced marked muscular tension under two strongly contrasting situations—a situation in which all tension apparently was directed toward support of the sucking activity and a situation in which tension was due mainly to excitement and diffuse motor activity

[15]Earlier records (27) indicate that gripping pressure of quiet infants is fairly steady while that of restless infants fluctuates in accordance with the degree of restlessness displayed

Curiously enough, *D* on 10 occasions took place when infants were sucking, mouthing or resting with the difficult nipple in the mouth. In one of these instances when the nipple had been withheld for two minutes, the infant was tense and restless during the first stage of *D*, in another instance the infant was alternately tense and relaxed as he sucked and mouthed, in both instances, however, sucking was sporadic. In eight instances the infant was physically quiet or quieting rapidly.

T sometimes increased during sucking and mouthing of the nipple following a period of strong sucking However, *T* usually declined during mouthing The effects of restlessness and fretting in thwarting situations frequently carried over into succeeding feeding situations and accounted in part for the fluctuations in gripping pressure during *D*. When *T* was present, turgescence frequently increased during the first strong sucking at the easy nipple

Comparison of the sucking conditions attending the onset of *T* and its decline showed that in general *T* occurred when food was withheld, or when it was obtained only with difficulty, i e, the amount of food acquired did not compensate for the energy expended in its obtainment. *D* took place when food was easily acquired, or the amount of food obtained was adequate to the energy expended. Hence neither strong sucking alone nor mouthing were *T*-producing conditions. As a matter of fact, in several instances sucking pressure was greater during *D* than during *T*, and mouthing occurred during both *D* and *T*. However, variations in sucking pressure were greater during *T* than during *D*

In summary, it can be stated that *T* is accompanied by restlessness, frequent fretting or crying, marked alternations in muscular tension, and vigorous body movements most of which have no connection with the sucking activity *D* is accompanied by general quiescence during which the muscles may be in a state of complete relaxation or in a state of sustained tension The contrast between conditions attending *T* and *D* is reflected by the marked fluctuations in gripping pressure in the former instance and by the steadiness of gripping pressure in the latter instance.

II. Discussion

1 *Non-Nutritional Sucking* Observation of infants' sucking reactions raises some interesting questions. Why do some hungry

infants in apparent contentment suck for several minutes at a dry nipple? Why do they stop nourishing during the feeding period and play with the nipple? Why do infants suck at a dry nipple, thumb, or finger after the hunger craving is satisfied?

At birth most of the infant's waking time is concerned with feeding. When he is satiated, he drops off to sleep. As he gets older, his waking periods become longer and body activity and restlessness increase. The increase in body activity enhances the opportunities for accidental or purposeful contact of the mouth with objects near him, viz., thumb, fingers, clothing, etc., and sets the stage for sucking which, although originally concerned with food-getting, may now be pursued as an end in itself.

The older infants frequently mouthed or tongued the bottle nipple, or pushed it from side to side of the mouth or sucked with the corners of the mouth ajar in all three bottle situations. The occurrence of these types of activity at feeding time, accompanied by occasional smiling, indicates that the contact of mouth with nipple may be a pleasure-giving experience or a playful activity. *T* never took place under the above conditions. On the other hand, mouthing and weak and false sucking occurred occasionally in abbreviated form between periods of restlessness, fretting or crying in the difficult nipple situation in the presence or absence of *T*. The indications are that so-called pleasure sucking activities have little or no connection with *T*.

It is not the purpose of this study to review all the literature on pleasure sucking or to interpret present results psychoanalytically. However, attention is directed to a few references which bear directly on the subject of non-nutritional sucking.

Psychoanalysts attach peculiar significance to sucking in the interpretation of libidinal aim and expression. According to Freud (25) the oral region is one of the three erogenous zones in the excitation of which the sexual aim of the infant (the production of gratification) is realized. When, therefore, an infant sucks contentedly without taking in food he is obtaining the sensual gratification which comes from the excitation of the oral zone.

Bernfeld (6) considers pleasure sucking by the infant as harmless in itself. He states that Freud does not ascribe adult sexuality to the infant and that the term "sexual," an unfortunate word under the circumstances, embraces all tactual pleasures. Lindner

(47) classifies pleasure suckers as (*a*) simple suckers of foreign objects and of parts of the body and (*b*) those who combine sucking with an auxiliary activity such as fingering some part of the body.

Woodcock (69) believes that sucking of thumb, fingers, pacifiers, etc., need not necessarily be associated with sexual behavior. The sucking activity assumes significance because of the pathological conditions which may result from sucking habits.

According to Stern (58), although sucking serves primarily as a means of acquiring food, it later is practiced as an end in itself. The child resorts to sucking objects, viz., thumb, fingers, nipple, and other objects, merely for the organic pleasure he derives from the act. Pleasure sucking is often carried on with great vigor. Stern, in discussing the psychoanalytic interpretation of pleasure sucking and the physical expression associated with it declares, "We may therefore in great measure accept the actual statement of psychoanalysis concerning organic pleasure in infancy without necessarily agreeing with their sexualistic inferences" (58, p. 131).

In this connection it is noted that of the 2,731 sucking experiments performed by Jensen (37) 604 involved dry sucking (sucking on air). Inasmuch as the infant derived no nourishment in these situations (there were no swallowing movements) the sucking that occurred may be regarded as of either reflex perseverative or pleasure-giving nature or both. Two of his statements are significant. "Ten infants sucked on air continuously for 15 minutes after their regular feeding and were quiet until the next feeding period" (p. 471). "Immediately after the bottle is empty, swallowing ceases though sucking continues (shown in 100 per cent of the cases where the bottle was emptied)" (p. 468). Now Freud (25) states that while the child is taking nourishment it is also enjoying the gratification which comes from the sucking reaction itself. This pleasure enjoyment the child seeks to prolong by sucking the thumb, finger, or other object, in this case, the nipple.

Levy (45) argues against the use of too freely flowing nipples on the ground that insufficient sucking activity is one of the frequent causes of finger and thumb sucking. On the other hand, if sucking at the difficult nipple can produce the results described above, perhaps the use of nipples which yield milk only at great pressure should be avoided. By the same token, extended delay in feeding and coercive use of an already rejected nipple should also be avoided.

'veral reasons may be advanced for the prevalence of non-itional sucking (*a*) In the first place sucking is an easily per-ıed native reaction When sucking is carried on with little nditure of energy during rest intervals in the feeding process, ı feeding, and between feeding periods, it is almost as easy the infant to suck as to lie still (*b*) Inasmuch as sucking *per se* ıds tactual and probably proprioceptive pleasure, the infant ongs the pleasure-giving experience. (*c*) The total food-getting ıtion, involving tactual, proprioceptive, olfactory, gustatory and mal sensations with their affective accompaniments, probably es as an incentive for the continuation or reinstatement of the ing activity after hunger is gratified (*d*) Sucking, a well ınized reaction at birth, probably affords a ready and con-ent outlet for the excess energy of restless infants, whereas the e unorganized and diffuse movements of other parts of the y may not be adequate to the situation (*e*) Sucking is an easily ted response which becomes conditioned to a great many diverse ıuli during early life

Common Occurrence of Thwarting in Everyday Life There othing new or startling about thwarting as it occurs in this study. ınts are frequently thwarted in some way at feeding time They not always fed just on time They are hungrier and therefore ıe impatient at one time than at another The nipple becomes gged, or it gives milk too fast or too slowly There probably are perfect bottle nipples, and mothers' breasts differ greatly with ɔect to the amount of pressure required to release milk Nearly studies on infant feeding present situations in which hamper-occurs Canestrini (12) used breathing curves and fontanel sations to show differential reactions to taste Sour, salt, and er solutions caused restlessness and irregularities in the breath-and fontanel curves Kasahara's infants (39) sucked milk at ıperatures below 20° C and above 40° C. When Pratt, Nel-and Sun (52) dropped water of a temperature of 8° in in-ıts' mouths, avoidance reactions were numerous Jensen (37) ıoduced a variety of disturbances in the sucking situation, viz., ,h and low milk temperatures, salt solutions, pinching the toes, lling the hair, dropping the infant four inches, holding the nose, l air sucking. Reactions to these thwartings included facial ex-

pressions of disgust, irregular sucking, avoidance, and sometimes renewed sucking

Preyer (54, pp 147, 313) realized that his infant was often thwarted The child was emotionally upset at being denied things that he craved From the beginning he refused to feed from the left breast because of some inconvenience and on the sixth day he actually screamed when put in position for this breast The work of Cramer (16), Basch (4) and Barth (3) in classifying breasts as easy-sucking and hard-sucking suggests that organic imperfection at the food source may be responsible for such refusals. On the other hand Cameron (11) states that breast babies frequently experience difficulty in sucking due principally to mechanical imperfections in the sucking apparatus.

Within our culture[16] breast weaning in many instances must be regarded as a thwarting situation. The infant is frequently removed from the breast within the first six months. However, he seldom surrenders to this indignity voluntarily In many instances weaning is accomplished only under the greatest difficulty. In a few cases the overt reaction of the baby to the weaning process fails to reveal any indications of thwarting *Lan*, for example, submitted to bottle feeding without any difficulty Mothers occasionally state that the infant prefers the bottle to the breast and the spoon to the bottle. There probably are physiological reasons for these indicated preferences

Outside of those conditions which cause physical pain there probably is no more effective way of creating a thwarting situation for the young infant than the method employed in this study, viz, delaying or interrupting the feeding process Although responses to the thwarting situation are classified as kicking, twisting, arching, crying, etc, there is no difficulty in recognizing the emotional tone underlying the responses.

3 *Sucking, Thwarting, and Body Tension.* The oral region, diaphragm and abdominal walls all function in carrying on the sucking activity. Observations show that the greater the strength of the sucking reactions, the greater the contraction of the abdominal walls However, whereas the jaw and other parts of the oral region

[16]The time of weaning varies considerably for different peoples (6, pp 245-260).

the abdomen assumes a state of more or less sustained tension ›ng sucking the tensing of the leg muscles in slow flexion, stiff on and bracing the feet in arching the back may have been 'd by the tightening of the abdominal walls—plurı-muscular ıation (17) *In keeping with the more or less static tension* ed by the abdomen and legs, gripping pressure on these occa- was always steady. It may well be that this added tension ces the sucking activity much in the same way that clenching ıws and gripping the hands together reinforces the knee 36)

ording to Woodworth (70, p 185) "Tension may very prob- e the feeling of tense muscles, for tension occurs especially in ancy, and muscles are tense then." Later he says, "Striving e, attainment brings the feelings of release"

ıger is "fundamentally an organic state. ." "It typically s the preparatory reactions of seeking food" (70, pp 79-80). case of the infant this organic state is evidenced by restlessness, nent and a general increase in tension of bodily musculature, Woodworth refers to as "damned-up energy" When the in his progress toward the goal encounters a barrier "his ıse is effort, or increased energy put into his movement to- the goal" (70, pp 83 and 536). Failure is likely to make ıbject angry The situation at least is one which in most ces brings forth unnecessary movements and marked alterna- ın muscular tension When the barrier is removed tension due ːitement subsides—provided that the hampering was not too ıously enforced or too long continued—and the body muscula- ıssumes a state of more or less static tension Increase or ıse in the strength of the sucking movements is accompanied corresponding increase or decrease in muscular tension The ıse in tension is indicated not only by a rise in gripping pressure lso by unmistakable reinforcing movements of limbs and trunk, depressing the abdomen, flexing the legs sharply or extending stiffly, or bracing the feet against the pad and arching the

Observation of Tumescence by Other Investigators *T* is bly very common among male infants from the first day of life. e are varying degrees of T, some of which are of so mild a form escape observation. In all cases herein reported the two or

three observers present agreed upon the presence of the phenomenon before it was recorded. However, other instances of probable T were noted

Infants are seldom naked during feeding so that the presence of T usually goes unnoticed If they were more frequently unclothed at least some of the conditions contributing to T and D would long ago have been common knowledge Of course the investigator is always confronted with the age-long taboo against investigations of this type If T is as common with sturdy male infants as this study indicates, it is unlikely that mothers have not observed the phenomenon, more probably, cultural impositions have prevented parents from relating their observations and led them to regard such behavior in their own infants as uniquely bestial. It is most interesting to note that following the disclosure of these results numerous doctors, nurses, and parents have come forward with evidence substantiating the fact of the frequent occurrence of T in infancy

T in early life has been reported by several investigators. For example, Watson (67) states that although the stimulation for T is unknown, it can occur at birth Blanton (9) reports five instances of T within the first four days of life. Moll (51) states that penial tumescence occurs in childhood and in fact even in infancy. The phenomenon may be produced by external irritation of the genital organ or by a full bladder According to Moll, sucking movements are in no way connected with the child's sex life Christoffel (15) observes that male babies at birth experience penial engorgement at the time of micturition T therefore foretells micturition—a condition which is gradually lost in the course of years, as micturition comes under control This early experience is later succeeded by the morning T due to bladder pressure Christoffel adds that hunger makes infants restless while the pressure of urine quiets them Micturition occurs not during deep sleep but in partial or entire wakefulness. He states that Russian writers have noted that control of urine during sleep is characteristic of the infant Micturition is a pleasant experience which may be accompanied by pupillary expansion. Balıassnikowa and Model (2) say that vigorous sucking by very active infants was accompanied by T which lasted throughout the sucking period and continued for several minutes *after the breast was removed* (Italics mine). "Glanz

der Augen" was often present on these occasions *T* apparently was associated with excitation of the vegetative centers

The presence of *T* has been observed in immature chimpanzees and monkeys and in adult animals In nearly all instances the conditions under which the reported phenomenon occurred involved excitement due to physical restraint or to thwarting of some sort

According to Bingham (8) social stimulation of the young chimpanzee apparently serves to accentuate sexual activity. In the excitement attending the presence of visitors, *Billy* experienced *T*. *Pan* revealed *T* when he was forcibly restrained on the measuring plane *T* occurred "at the end of increasing excitement" which was accompanied by an increased output of energy "As excitement increased, and the avenue of available motor expressions became more restricted, a new outlet was suddenly opened" (8, p 142) Bingham relates other situations wherein this phenomenon occurred in which there were no apparent indications of restraint

Hamilton's observations on the sexual tendencies of monkeys and baboons caused him to state (29, p. 317) "It is possible that hunger for access to an enemy impels the macaque toward the manifestation of sexual behavior." Stone in his study of "The Congenital Sexual Behavior of the Young Male Albino Rat" (59) found that aggressiveness was associated with sexual experience. Miller (50), in describing the actions of a half-grown male baboon which had succeeded in removing the baseboard from the front of his cage, states that the baboon strongly resisted the efforts of the keeper in replacing the board and in so doing experienced a full erection. Tinklepaugh (62) found that in chimpanzees and monkeys thwarting produced sexual responses and that the frequency of the responses decreased with the age and experience of the animal

Feeding certainly has a marked conditioning influence on the chimpanzee, both male and female *T* occurred frequently and with some males very consistently at the sight of food One day when Bingham was holding food near *Pan* but causing the animal to wait for it, *Pan* strongly portrayed genital tension At another time when *Pan* was restrained and the food withheld he became angry Eventually *T* appeared (8, pp 133-147) It has been reported[17] that in the instance of anthropoid apes and certain other

[17]Abstract of proceedings at Dr Clark L Hull's informal seminar of February 12, 1936

primates T did not occur specifically in response to food, but rather in response to relief of tension arising from frustration or the withholding of rewards However, there were other occasions in which general excitement was sufficient to elicit sexual excitement

Lashley and Watson (43) *observed* T *in the instance of a rest*less rhesus monkey of two months when its mother picked near the sex organs Zuckerman (72) noted the phenomenon in a male monkey of six months Finally, Bingham (8, p 79) states that play threats, erect advances and fighting are "antecedents of copulatory behavior"

In the present study, although T frequently occurred concurrently with strong sucking, it was apparent that this activity alone was not adequate to produce the phenomenon For example, T never *occurred during strong prolonged sucking* at the breast or easy nipple. Again, whenever T was present, strong or weak sucking at the breast or easy nipple was always accompanied by rapid D As a matter of fact, T always occurred when infants encountered a difficult or irritating situation, such as delay in feeding, withholding the breast or easy nipple, sucking air, or sucking at the difficult nipple The situation, as already stated, not only produced marked tension in the skeletal musculature, particularly noticeable in the abdomen and legs, but was frequently accompanied by an unmistakable display of "anger"[18]

5 *Possible Reasons for the Occurrence of Tumescence.* No unique or alarming sexual significance need be attributed to the presence of T in the male infant (30) Kuntz (42, p 301) states that "sexual excitation is a complex phenomenon which depends largely on the functional state of the internal secretory tissue in the sex glands It cannot be brought about during childhood until the sex glands, particularly the internal secretory tissue, have become functional If the sex glands are removed early, the development of the seminal vesicles and prostate gland is arrested and sexual excitation can never be achieved." In this connection Becker's (5) histological examination of the external genitalia of

[18]It was sometimes difficult to determine whether or not "anger" was always present during the onset of T Although sucking at the difficult nipple frequently resulted in fretting or crying, there were occasions when this situation produced only general restlessness accompanied by stiffening of the body, sharp flexion of the legs, or arching of the back

premature and full term infants points to very incomplete development of the receptor organs

Available evidence from observations of infant behavior and from physiological experimentation on animals points to a purely reflex explanation of T The phenomenon may be produced by mechanical stimulation of the glands or shaft of the penis, by pressure-stimulation from a full bladder and by stimulation of the visceral rami of the sacral nerves (42, pp. 296-298, 33, 1044-1045) Similarly, "vasodilation and engorgement of the erectile tissue may be elicited reflexly by warm applications to the organ and surrounding parts" (42, p 299), as well as by gentle rubbing in the process of handling and cleaning the infant The center which mediates reflex T probably is in the sacral spinal cord, although certain investigations (42, pp 297-298; 33, p. 1045) indicate that the lumbar region may to a certain extent subserve the functions of the sacral centers.

It is possible that the excitement attending the hampering situations may have produced T directly by excitation of the parasympathetic nervous system or indirectly by increased abdominal pressure due to sympathetic innervation

Cannon (13) has shown that in general the two divisions of the parasympathetic nervous system function in contributing to the pleasure and comfort of the individual On the other hand, the presence of strong emotion, viz, fear or anger, which energizes the sympathetic system, abolishes these pleasurable states. It is common knowledge that fear and anger inhibit sexual excitement in the adult (42, p 459, 13, pp 334-337) and, as far as is known, there is no reason to believe that the sympathetic and parasympathetic systems function otherwise than antagonistically in the emotional life of the infant

It has been suggested that whereas frustrations which result in fear or anger typically inhibit T, certain kinds of frustrations which bring about strong emotional upheavals characteristically energize at least some parts of the parasympathetic division Indeed, Cannon (13, p 31) states that "great emotion, such as is accompanied by nervous discharge via the sympathetic division, may also be accompanied by discharges via the sacral fibres" "The orderliness of central arrangements is upset" (p 338) and it is possible that under these conditions the opposed innervations discharge simultaneously

rather than reciprocally. Later he states (pp. 344-345) "that any high degree of excitement in the central nervous system, whether felt as anger, terror, pain, anxiety, joy, grief or deep disgust, is likely to break over the threshold of the sympathetic division and disturb the functions of all the organs which that division innervates." For example, mild emotional states, such as worry and anxiety, may cause constipation by inhibiting the activity of the colon, whereas strong emotional stress often increases the activity of this organ as well as the bladder (pp. 31, 338-339). It appears then that sacral innervation in times of intense emotion is entirely possible. Furthermore it is conceivable that under these conditions the functions of this division of the parasympathetic nervous system may extend beyond activities connected with the colon and bladder.

Furthermore, there is reason to believe that excitement does not invariably produce comparable upsets in all individuals. Kuntz (42, p. 460) states "that emotional excitement may bring about either impaired digestion due to sympathetic stimulation or gastro-intestinal hyper-activity as a result of parasympathetic stimulation or sympathetic inhibition." In fact Lueders (49) finds that in excitement gastro-intestinal function is accelerated in some patients with psychoses.

During the onset of *T* there was marked tension in the abdominal and leg muscles. It is well known that adrenal secretion is increased in emotional excitement. One result of the presence in the blood stream of the added dose of adrenin is its invigorating effect on the trunk and limb muscles. In this connection Cannon (13, p. 93) states,

> Both in excitement and in strong exertion the blood is forced in large degree from the capacious vessels of the abdomen into other parts of the body. In excitement the abdominal arteries and veins are contracted by impulses from the splanchnic nerves. In violent effort the diaphragm and the muscles of the belly wall are voluntarily and antagonistically contracted in order to stiffen the trunk as a support for the arms.

It is probable then that *T* may be produced as a result of pressure-stimulation of the sensory neurones of a distended bladder. There is reason to believe that the reflex acts of *T* and micturition are

closely related[10] (15) Early morning T is usually attributed to distention of the urinary bladder which in some way, probably by pressure, stimulates the nerves which mediate T Similarly, T which occurs during the act of defecation, in which abdominal and pelvic muscles contract sharply to crowd the internal organs of the lower viscera, probably may be accounted for on the same principle. Now the afferent paths for T lie within the pudic nerve, and the sensory paths for reflex contractions of the bladder lie in the nervi erigentes, or the nervi erigentes and pudic nerves (The motor paths for the reflex acts of both functions lie in the nervi erigentes.) If pressure from within the distended bladder is the effective stimulus for reflex contractions of the bladder, it is possible that, inasmuch as the afferent paths for both bladder contraction and T lie within the pudic nerve, pressure stimulation of the sensory fibres leading to bladder contraction may also affect the fibres leading to engorgement of the penis Furthermore it is quite conceivable that in the excitement of a thwarting situation the marked contractions of the abdominal muscles against a full or partially filled bladder may be at least as effective as a distended bladder alone in producing T. In fact it has been suggested that extreme abdominal pressure alone may evoke T in much the same way that straining during the act of defecation produces it.

Thus in the present situation T may have been produced by strong abdominal pressure due to the general increase in diffuse activity within the central nervous system (and skeletal musculature) when the activity finally attained the stage at which it was effective in exciting into action the autonomic nervous system If this explanation be correct, onset of T should be attended by an increase in body tension While the results in general show an increase in the strength of gripping with the onset of T, the significant feature of the curve is its frequent and erratic fluctuations in tension which indicate the high degree of excitement experienced by the infant Thus, to the extent that gripping strength is a valid index of general body tension, and that excitation of the autonomic nervous system may be expected to produce great alternations as well as increase in body tension, the results appear to support this explanation

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[10]A forthcoming paper based on full day observations of naked infants will cover the subject.

According to Taylor (61, p. 166) the blocking of an impulse or tendency may bring about alternative responses such as "(*a*) various striped-muscle patterns, (*b*) the emergency emotions, (*c*) the mechanisms of laughter and crying", etc. But, he adds, *alternative response mechanisms* are inadequate to relieve the "basic life-maintaining urges of hunger, thirst . . . . These urges are relieved only so far as we know by the specific provision of nourishment, . . ." (p. 172). Furthermore, when in a highly exciting situation the organism is "set" for violent exercise of its bodily functions, an infant whose capacity for movement is limited to kicking, squirming, threshing about, twisting, arching and crying, may be quite unable to discharge in the normal manner of an adult the surplus energy built up by excessive secretion of the adrenal glands. As a result *it is conceivable that the "overflow" of energy* leads among other things to violent enough contractions of the abdominal walls to produce T.

Other theories have been proposed to explain occurrence of T in the present experiment. For example, it has been suggestd that inasmuch as salivation and T are both under control of the parasympathetic division of the autonomic nervous system, and inasmuch as the various response mechanisms of this division are as yet in a state of incomplete individuation, a situation which brings about increased salivation, viz., sucking at a dry nipple or one through which milk is obtained only with difficulty, may possibly elicit other related responses, among which is T. In other words, the parasympathetic mechanisms may tend to function more or less as a unit in early infancy and to become functionally differentiated only at a later date. This theory does not explain why T occurs at withholding of the nipple unless it is assumed that hunger or the mere presence of food or both is sufficient cause for the increased flow of saliva.

Now it is possible that severe muscular tension and violent body movements may have caused T by retraction of the testes or agitation of the penis. However, inasmuch as T frequently occurred when there was little or no movement of the latter organ and retraction of the testes followed or accompanied the process of T, this explanation of the onset of the phenomenon appears to be inadequate.

It has also been suggested that T in this experiment occurred as a direct result of thwarting, just as bristling occurs in a hungry

dog on attempts to remove his food. In this sense T is just one of the reflex enlargement processes characteristic of rage, which include such overt reactions as inflation of the trunk, clenching of the fists, tensing of the musculature and erection of feathers, hair and tail However, the evidence against this theory is overwhelming (42, 295-301)

From a psychoanalytic point of view the occurrence of T, resulting from frustration at the oral zone, may be regarded as representing a shift in focus of libidinal expression from one pleasure zone (oral) to another (genital).[20] If this explanation were correct, a decrease in body tension would be expected to accompany the onset of T, which certainly is not the case

Of the several explanations of the process of T, this paper is inclined to favor the ones which place emphasis on abdominal pressure Under normal feeding conditions the desire (drive) for food by a hungry infant is sufficiently strong to call forth vigorous sucking and gripping. It has already been noted that when sucking is well under way it occurs smoothly and regularly at uniform strength while gripping tension becomes constant When thwarting is introduced in the situation activity is not only increased, it is frequently disjointed Instead of apparent contentment with his situation, the infant manifests restlessness or anger and frequently aggression The activities involved in the feeding process lose their smoothness and regularity, and movements extraneous to the sucking pattern come strongly into play Of these movements perhaps the most conspicuous are the severe contractions of the abdominal walls While other motor patterns varied during the onset of T, marked abdominal pressure was always present

[20]Professor Earl Zinn of the Department of Psychiatry and Mental Hygiene of the Yale University School of Medicine has supplied the following interpretation of Freud's theory of Libido Displacement. "In terms of the theory of libido economy blocking libido gratification at one outlet would result in increase in tension, and the expectation would be that attempts would be made to reduce this tension (according to the pain-pleasure principle) by the utilization of other erogenous zone outlets, provided these outlets were functional" For further information on Libido Displacement see Healy, W, Bronner, A F, and Bowers, A M, The structure and meaning of psychoanalysis New York Knopf, 1930 Pp. xx+482

I Summary and Conclusions

1. Differential responses were obtained to breast feeding, air sucking, easy and difficult sucking at the bottle, and delay and interruptions in feeding.

2. Concurrent records of sucking pressure, gripping pressure, and general motor activity, indicate that the order of preference in sucking is as follows: breast, easy nipple, difficult nipple, and dry nipple. This order of preference is also indicated by the persistence of the sucking activity.

3. In general there was a decrease in sucking pressure, gripping pressure, and bodily activity, throughout the feeding period. The decrease was sometimes gradual and sometimes fluctuating

4. The ratio between sucking and swallowing movements varied considerably for the different feeding situations Frequently several sucks preceded a swallow On other occasions two or three successive swallows followed a series of sucks.

5. Air sucking occasionally continued for several minutes.

6 Contented feeding, in which the amount of milk acquired compensates for the amount of energy expended in sucking, was evidenced by (*a*) regularity of sucking movements, (*b*) uniformity of sucking pressure, (*c*) steadiness of gripping pressure, and (*d*) infrequency of changes in bodily posture Hampered feeding, which includes air sucking, delay and interruptions in feeding, and difficult obtainment of milk, was characterized by (*a*) strong but sporadic sucking of varying pressure or rejection of the nipple, (*b*) rapid and marked fluctuations in gripping pressure, (*c*) general restlessness, (*d*) increase in muscular tension, (*e*) excitement, and (*f*) frequent aggressive bodily movements.

7. The records show that the tension of the flexor muscles of the hand varies directly with the strength of sucking. To the extent that this tension is an index of general body tension, the latter also varies directly with the strength of sucking.

8 Tolerance of hampering situations varied greatly from infant to infant, and from time to time in the individual infant.

9. With the exception of the breast feeders, hampering was more effective in the earlier part than in the later part of the feeding period in producing overt manifestations of frustration With the breast feeders these responses apparently could be produced at almost any time during the feeding period.

10 Penial tumescence (T) was accompanied by restlessness, frequent excitement, and marked muscular tension, sometimes sustained but usually fluctuating. Detumescence (D) was accompanied by general quiescence and steady, sustained muscular tension The stronger the sucking during D, the more marked the tension and the slower the D.

11. Although T did not always occur in hampering situations, every instance of observed T occurred under conditions wherein the sucking activity was hampered Elimination of the hampering situation in each instance was followed by D

12 The duration of T varied considerably The phenomenon occasionally persisted for several minutes during sucking at the difficult nipple.

13. Genital responses did not occur during strong sucking at the breast or easy nipple

14 T is probably of common occurrence in male infants. It probably occurs even in pre-natal life.

15 Physiological evidence and the behavior of these infants indicate that marked abdominal pressure is probably the most effective stimulus for T as observed in the present situation

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THE ELECTROENCEPHALOGRAM DURING NORMAL INFANCY AND CHILDHOOD: I RHYTHMIC ACTIVITIES PRESENT IN THE NEONATE AND THEIR SUBSEQUENT DEVELOPMENT*

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A INTRODUCTION

Observations on the electroencephalogram (*e e g*) during normal infancy and childhood have been concerned chiefly with a comparison of the alpha wave component in children of various ages with the familiar 10 per second waves usually seen in the adult Of the existing data, those of Lindsley (19) [cf also Loomis, Harvey, and Hobart (20), Berger (5), Kreezer (15), and Davis and Davis (6)] establishing the nature of the frequency variation of these waves with age are the most complete With one minor exception, Lindsley's findings relative to the growth of the alpha rhythm have recently been corroborated by the writer (25) Other rhythmic components of the *e e g*, well established long before the alpha waves appear and apparently emanating from the sensory-motor region, were also described in the latter report It is with these latter rhythmic activities which precede the alpha waves in development that the present paper is specifically concerned Supplementary data are presented indicating the various properties of these rhythms in the neonate In addition, an attempt is made to outline the growth changes undergone during infancy and early childhood by the various waves

B TECHNIQUE

Established technique was employed Fluctuations in electrical potential occurring between two electrodes applied to the intact scalp were led off to appropriate amplifiers and the amplified potentials were then recorded by means of an ink-writing undulator (Garceau and Davis, 10) In practice a system of three uniform inde-

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pendent amplifies with balanced input (Matthews, 23) could be employed to operate three undulators which wrote on the same paper tape, permitting simultaneous recording from three separate pairs of electrodes on the scalp

The observations were carried out under uniform conditions with the child lying at rest and in semi-darkness within an electrically shielded and partially sound-proofed chamber. This chamber, which housed the input stages of the amplifiers in addition to the bed upon which the child lay, was set up in one corner of a large and relatively quiet laboratory room

For electrodes we have usually employed small cylindrical pellets of lead 5 to 6 mm in diameter and 5 mm long, each force-fitted into the lumen of a small soft rubber grommet These electrodes were held against the scalp by means of a snugly fitting rubber bandage, as shown in Figure 1 Bipolar leads were uniformly employed Before each electrode was applied, a small patch of hair was removed and the underlying scalp cleaned with alcohol Sanborn electrode paste was employed to reduce contact resistance Under these conditions the *DC* contact resistance usually measured between 2,000 and 5,000 ohms Electrode positions were determined in approximate relation to underlying cortical structures by measurement with respect to certain anatomical landmarks and were standard from experiment to experiment (cf. for example Figure 5).

Observations were made upon a total of 71 normal children. Included in this group were 14 infants and young children ranging in age from one day to 4½ years upon whom individual serial observations were made over periods ranging from 4 to 18 months In this serial study the interval between observations has depended upon the age of the child Recording on the newborn usually began on the first post-natal day or as soon thereafter as the child was available It was continued twice a week for the first three weeks, thereafter once a week until the end of the sixth month, and twice a month from then until the end of 18 months. In children over 18 months the interval between observations was one month until the age of three years and two months beyond this age. In addition to the serial recordings incidental observations were made upon a group of 11 newborn infants Supplementary cross-sectional data were also obtained from single observations upon a group of 46 children varying in age from 3 to 17 years

FIGURE 1
RUBBER BANDAGE ELECTRODE PREPARATION AS EMPLOYED IN A 9-MONTHS-OLD INFANT

C. Results

1. *Rhythmic Activities Present in the Neonate* The character of the *e.e.g.* of the newborn infant depends in large measure upon the placement of the electrodes employed Thus, although tracings taken with bipolar leads restricted to the occipital lobes or to the extreme frontal areas may fail to show any noticeable potential fluctuation at or soon after birth and may give typically a flattened-out "baseline" pattern, records obtained with electrodes placed . various positions over the sensory-motor region may exhibit considerable and varied electrical activity. The activity in question is to be observed only during sleep or during states of drowsiness and relaxation immediately preceding sleep; if the infant is awake and moving, it is abolished. The pattern of the activity may be described as predominantly random or irregular with the occasional appearance of rhythmic waves which occur in short series segregated momentarily against the prevailing irregular background

These rhythmic sensory-motor area waves range in frequency from one to approximately 20 oscillations per second.[1] The various waves, however, are not distributed uniformly over this frequency range but tend to be grouped in such a way as to suggest several distinct frequency bands. The prevailing waves are slow and vary in frequency from 3½ to about 6 per second although they appear usually at 4 or 5 per second These waves are conveniently referred to as "drowsy waves" because they appear characteristically in older infants during pre-sleep drowsing states Similar waves have been described as appearing during sleep in adults by Gibbs, Davis and Lennox (12) and Davis, Davis, Loomis, Harvey and Hobart (7) Three other well-defined frequency groups also appear. The slowest includes waves varying from 1 to 3 per second with a mode probably at 2 per second. These very slow waves apparently correspond to the "delta" waves recently described by Walter (28, 29). The two other groups embrace waves ranging from 7 to 8 per second and from 12 to 14 (occasionally to 19 or 20) per second. To the writer's

[1]The so-called "beta" waves (approximately 25-40 per second) have thus far not been observed in the neonate This is no necessary indication of their absence however Because of the low efficiency of our undulators at frequencies in the beta range (natural period approximately 30 per second) and the low voltage of the beta waves, the latter might be present and not be recorded.

knowledge, the former intermediate frequencies have not been described. The 12 to 14 per second waves have their counterpart in the adult "spindles" first noted by Loomis, Harvey, and Hobart (20, 21). The frequencies between 8 and 12 per second have rarely been observed in the newborn although they are seen occasionally in older infants.

The amplitudes of the various waves range from 10 to 75μv approximately. Roughly, this dimension varies inversely with frequency, the slower waves tending to be of greater amplitude and vice versa.

Several examples of the slow rhythmic waves most often seen in the newborn are presented in Figure 2*a*.[2] These tracings were recorded simultaneously from three separate areas on the scalp of a sleeping infant three days old. It may be observed in these tracings that the two pairs of motor region leads (*B* and *D*) show definitely more activity than the occipital leads (*A*). In contrast to the flattened-out low voltage pattern shown by the latter, marked by few potential peaks rising noticeably above the baseline, the motor area leads show almost continuous potential fluctuation characterized by the recurrent brief appearance of slow rhythmic[3] waves varying in frequency from 3½ to 5 oscillations per second. The amplitude of these waves varies from 20 to 75μv. Such rhythmic bursts occur typically in short series of 3 to 6 waves, rarely in longer sequences. They may recur at intervals of only a few seconds in some infants or in others they may be separated by periods of minutes. During the time that the rhythmic waves are absent, the potential pattern is typically random, marked by sequences of slow irregular waves as is evident in Figure 2*a*.

The recurrent bursts of rhythmic activity persist only as long as the infant remains quiet and asleep. When he awakens, they are

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[2]The various tracings presented in Figure 2*a* and the following figures were selected as "typical" of the several rhythmic activities under the conditions and at the ages indicated. In general this meant selection of that approximate level of amplitude, length of sequence and degree of regularity observed most often during each run.

[3]In the present paper a sequence of potential is arbitrarily defined as "rhythmic" if there occur in continuous sequence three or more regular (approximately periodic) waves. With the gains usually employed, a minimum amplitude of 10μv could be clearly observed.

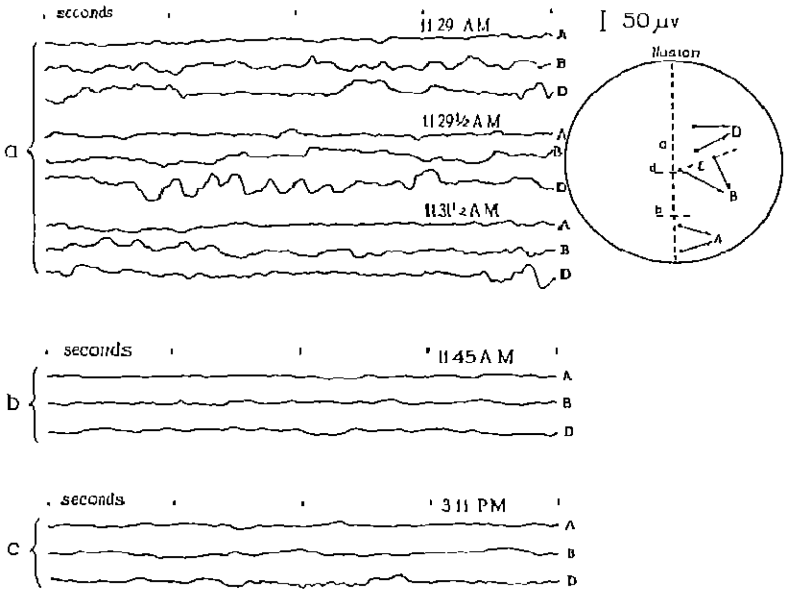

FIGURE 2

TRACINGS OBTAINED FROM A 3-DAY-OLD INFANT DURING WAKING AND SLEEPING

a The prevailing 3½-6 per second waves appearing over the sensory-motor area during sleep Occipital pattern baseline

b. Baseline patterns observed during the waking state from all areas

c The 12-14 per second waves appearing during sleep over the pre-central region Occipital and motor tracings baseline

Cf. explanation in text

Electrode positions shown in the schematic drawing at the right This drawing represents the scalp as spread out into a circular horizontal plane bound ventrally by the nasion, dorsally by the inion and on either side by the external auditory meatus Leads *A* occipital, along the midline (*a*) anterior lead just posterior to the lambda (*b*) and interelectrode distance 3 cm. Leads *B* motor, approximately over the central sulcus (*c*) medial lead 1 cm to the right of the superior rolandic point (*d*) and interelectrode distance 4 cm Leads *D* pre-central, posterior lead just posterior to pre-auricular line and 2 cm to the right of the anterior fontanelle, other lead 3 cm directly anterior

abolished and the tracings from any area then show a "baseline" pattern. The nature of this change may be seen in Figure 2*b*. In this instance the child awakened spontaneously and, after crying and

fussing for several minutes, quieted sufficiently for tracings to be taken The synchronous waves previously appearing over the motor area (Figure 2*a*) had now disappeared and all three leads showed the flattened pattern previously observed over the occipital lobes in sleep This observation has been confirmed on other newborn infants In a number of observations when it was possible to obtain records during an initial "awake" interval preceding sleep, it was found that a flattened-out pattern persisted until movement ceased and the eyes were closed. Rhythmic waves then usually began to filter in over the sensory-motor region correlatively with a noticeable increase in the general amplitude of the pattern. After several minutes the typical picture of recurrent brief bursts of rhythm against the prevailing irregular background was usually established

In Figure 2*c* are shown the 12 to 14 per second waves as they appear in the newborn. The tracings of this figure were obtained several hours after those of Figure 2*a* and *b* on the same infant and the electrode positions were the same. As before, the child was asleep In this instance, all three leads gave random low-level tracings, but this pattern was interrupted momentarily over the premotor area (leads D) by the appearance of a brief sequence of small, fast waves at 13 per second and averaging approximately 15μv in amplitude These latter waves are seen typically as here in occasional short isolated series and while they may be observed with electrodes placed anywhere over the sensory-motor region, they are maximum in amplitude and most consistent in appearance over the pre-rolandic area They may appear as here against a low voltage background, or they may be superimposed upon the slower delta or drowsy waves

The very slow delta waves and the intermediate 7 to 8 per second waves as seen in another 4-day-old infant are presented in Figure 3*a* and *b* The infant was apparently sleeping soundly when the tracings were obtained. As was observed with the first infant whose tracings are reproduced in Figure 2, rhythmic activity again was restricted to the sensory-motor area leads In Figure 3*a*, well-defined slow waves at about 2 per second appear under the parietal leads while both occipital and frontal leads present a baseline pattern Several minutes later (Figure 3*b*) rhythmic waves at about 7½ per second are also to be observed over the parietal area but the straight-line picture is still maintained over the other regions During this run, which lasted 40 minutes, the slow delta activity was observed several

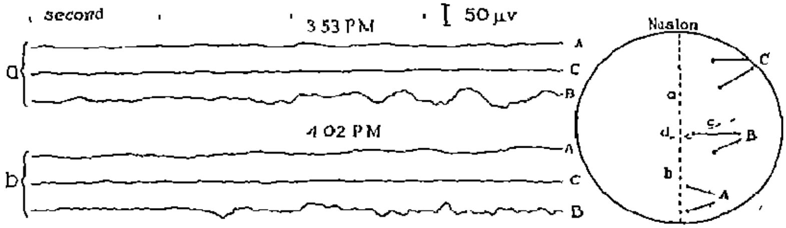

FIGURE 3

TRACINGS OBTAINED FROM A 4-DAY-OLD INFANT DURING SLEEP

a Delta waves at about 2 per second appearing over the post-central region

b The 7-8 per second waves as observed over the post-central area

Occipital and frontal tracings remain "straightline" Cf explanation in text.

Electrode positions Occipital leads (*A*) as in Figure 2. Leads *B* post-central, anterior lead 1 cm. to the right of the superior rolandic point, other one 4 cm. to its right posteriorly along a line forming an angle of 45° with the midline Leads *C* frontal, posterior lead 3 cm to the right of the midline just opposite the anterior end of the fontanelle and the other 4 cm directly anterior on the forehead

times in short, fairly regular sequences as seen in Figure 3*a* and always over the post-rolandic area The 7½ per second waves, however, were observed only twice. Much more prevalent than either of these were the familiar 4 to 5 per second waves described in Figure 2*a*.

Although the occipital and frontal areas typically exhibit baseline patterns in the newborn infant, the various rhythmic activities, particularly the very slow delta waves and the 3½-6 per second waves, occasionally may be observed briefly over both of these regions This is interpreted as being due to a momentary spread of activity from its source within the sensory-motor area. As they appear over the occipital or frontal areas, the waves are smaller, briefer in sequence, and less frequent in appearance than over the motor area Since they are best defined and most consistent when leads are restricted to the sensory-motor region, there appears to be little doubt that they emanate from this area.

So far, these various waves have been recorded in 15 neonatal or early post-neonatal infants Of these, 10 were 10 days old or less when first observed. The other five ranged in age from 12 to 25 days All of the several frequencies have been observed within three

days after birth. However, not every child showed all of the frequencies on the same post-natal day. One child, for example, showed all four of the frequencies on the third post-natal day, and another child when first observed on the twelfth day. In a third child, the three slower rhythms (1-3, 3½-6, and 7-8 per second) were all well defined on the first day, but the 12-14 per second waves did not appear until the twenty-third day.

When these various rhythmic activities began to be observed consistently in the newborn, the question immediately arose as to whether they represented true electrical activity in the brain or whether they might be artifacts produced by factors extraneous to such activity. Perhaps the most plausible source of such artifacts, if they did exist, would be in mechanical effects originating in beating of cortical blood vessels and reflected in the activity of the fontanelle. Berger (4) has already shown that there is no consistent relation between the *e.e.g.* and the pulsations of the cortical blood vessels in several cases of adults with bone deficiencies which permitted simultaneous recording of brain vascular changes and the *e.e.g.* Conditions are somewhat different in the newborn infant, however. In the latter, mechanical effects originating in the beating of the cortical vessels might conceivably set up related movements in the various cranial bone flaps since all of the sutures are open. If such were the case, then some consistent relation might be expected between the beating of the vessels and the various rhythmic activities observed. This possibility has been checked in a number of infants by measuring the pulse pressure curve in the arm simultaneously with the *e.e.g.* The pulse pressure curve, while probably displaced slightly in time in comparison with the fontanelle pulsations, should correlate uniformly with the latter. The comparison was accomplished by means of an arrangement (cf. Figure 4*a*) whereby changes produced inside a blood pressure cuff (placed around the upper arm) by arterial pulsations were impressed upon a carbon microphone. Changes in current in the microphone circuit were then impressed upon the input of an amplifier operating at a slow time constant, being ultimately recorded (Figure 4*d*) on the same tape with the *e.e.g.* Employing this procedure, we have in no instance observed any consistent relation between the pulse pressure changes and the various rhythmic fluctuations of the *e.e.g.*

This failure of correlation is to be expected. If the various

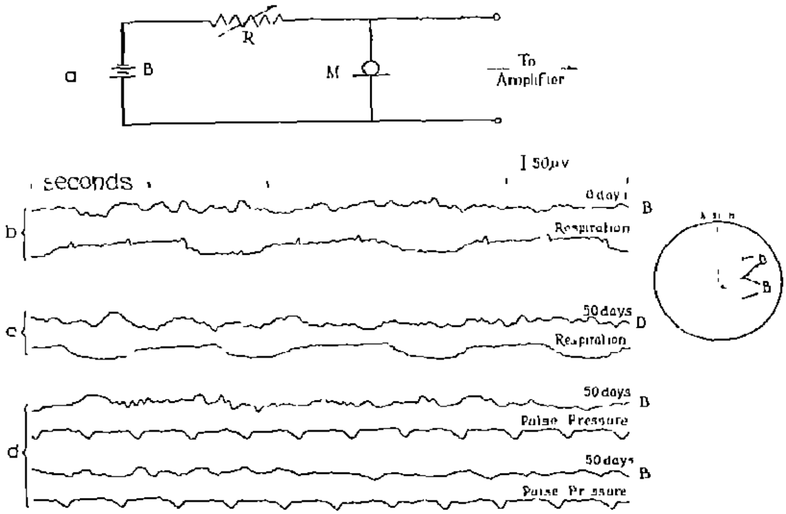

FIGURE 4

SHOWING LACK OF ANY CONSISTENT RELATION BETWEEN RHYTHMIC ACTIVITY IN THE *e.e.g.* AND OTHER PHYSIOLOGICAL RHYTHMS

Electrode positions for the *e.e.g.* indicated in the schematic drawing at the right. The microphone pickup circuit for the pulse pressure tracings is shown at *a*. *B* indicates battery, *R* variable resistance, and *M*, carbon microphone. Cf. explanation in text.

rhythmic activities of the newborn *e.e.g.* were due to mechanical disturbances originating in the beating of cortical blood vessels, then it is difficult to see why they should not appear over frontal and occipital areas as well as over the sensory-motor region. The various rhythmic activities, moreover, appear only irregularly during sleep and relaxation when the cortical vascular pulsations would be expected to be quite regular. It should also be noted that all of the rhythmic activities observed in the newborn undergo definite changes during subsequent growth (increasing in amplitude, length of series, etc.) while any possible mechanical effects are being correspondingly decreased by closure of the fontanelle and the various sutures.

The same arrangement was employed to record respiration simultaneously with the *e.e.g.* (Figure 4*b* and *c*). In this instance the cuff was placed around the thorax. By placing the cuff high up over

the chest, it was possible to record as well the pressure changes produced by the beating of the heart, these latter appearing as short spikes on the slower respiratory changes (Figure 4*b*) In these experiments likewise no consistent relation was found between the respiratory rhythm (or the heart rhythm) and the development of the rhythmic waves of the *e e g*

2 *Subsequent Growth Changes of Rhythmic Activities Present in the Newborn* The various rhythmic activities observed in the *e e g* of the newborn infant all undergo definite modifications during early postnatal growth These modifications involve change in the amplitude and regularity of the waves and in the number of waves appearing in sequence The writer, however, has so far observed no systematic alteration in frequency during development such as occurs with the alpha waves (19), (25), (26) The frequency dimension of the waves is apparently permanently established at birth

In order to indicate the nature of these early growth changes several groups of tracings have been selected from the records of two infants who have been subjected to intensive serial observations over a period of months In one of these infants the span of observation extends from birth to 5 months, in the other from 3½ to 13½ months Supplementary tracings are also presented showing the status of the various rhythms in older children (cf. Figures 5, 6, 7 and 8).

Considering first the serial observations on the two infants, it may be seen in Figures 5, 6, 7 and 8 that considerable development occurs during the first year of life. If one follows the course of each of the rhythms through this interval, it is noted that the bulk, if not all, of the developmental changes have apparently occurred by the end of the fourth month Present at birth, or within a few days after birth, merely in short sequences of attenuated, partially synchronized waves, each of the activities shows during this early period an overall increase in amplitude, a correlative increase in number of waves appearing in sequence, and a definite trend toward improved regularity of the waves It is to be noted that no change in frequency has occurred During the following 10 months, however, as indicated by the tracings on the other child, no such clear-cut developmental trends occur If one compares the various rhythms as they first appear in this child at the beginning of this interval and then at its end, it is noted that any definite overall growth

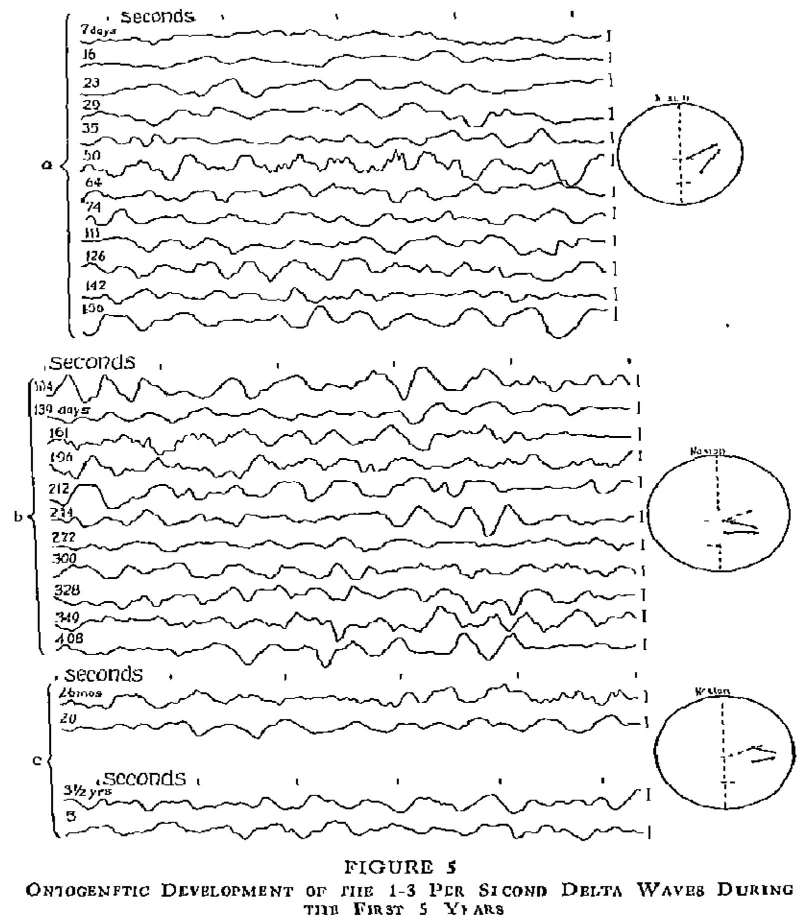

FIGURE 5

ONTOGENETIC DEVELOPMENT OF THE 1-3 PER SECOND DELTA WAVES DURING THE FIRST 5 YEARS

a. birth to 156 days in infant *A M*;
b 104 to 408 days in infant *C. D.*,
c 20 months to 5 years in different children Post-central electrode positions indicated in the schematic drawing opposite each set of tracings 50μv calibrations

Note here (similarly in Figures 7 and 8 below) the overall changes in amplitude, in regularity, and in length of rhythmic sequence from birth to 4 or 5 months in infant *A N*, and the lack of any noticeable developmental trend in baby *C D* from 3½ to 12 or 13 months or in various older children The development of the 3½-6 per second drowsy waves (Figure 6 below) is comparable except for an apparent decline in the amplitude of the latter waves and in length of rhythmic sequence in children over 3 years'

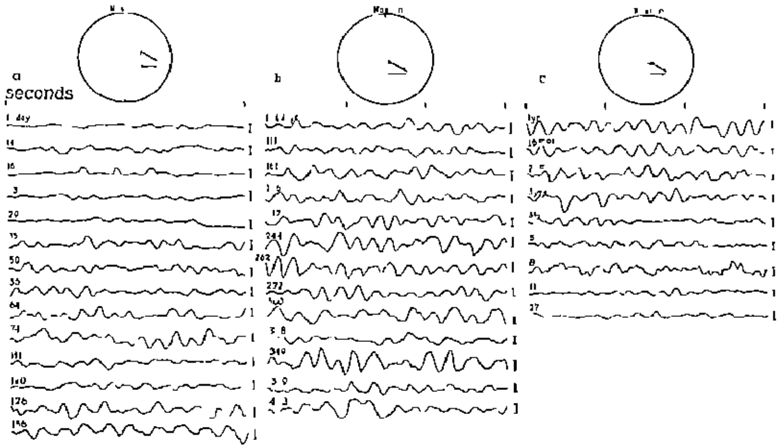

FIGURE 6

THE ONTOGENETIC DEVELOPMENT OF THE 3½-6 PER SECOND DROWSY WAVES

a birth to 156 days in infant *A N*,
b 104 to 408 days in infant *C D*,
c 1 to 27 years in various individuals.

Post-central electrode positions indicated in the schematic drawing above each group of tracings

50μv calibrations

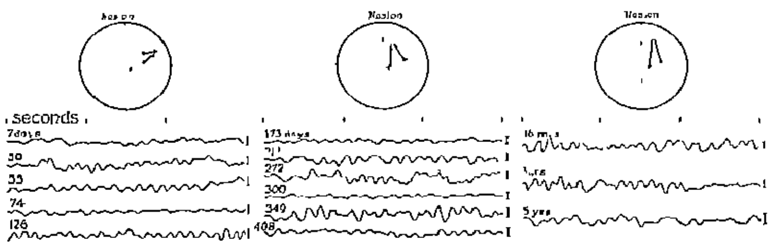

FIGURE 7

ONTOGENETIC DEVELOPMENT OF THE 7-8 PER SECOND WAVES DURING THE FIRST 5 YEARS

a 7 to 126 days in infant *A N*,
b 173 to 408 days in infant *C D*,
c 16 months to 5 years in different children

Pre-central and central electrode positions indicated in the schematic drawing above each set of tracings

50μv calibrations

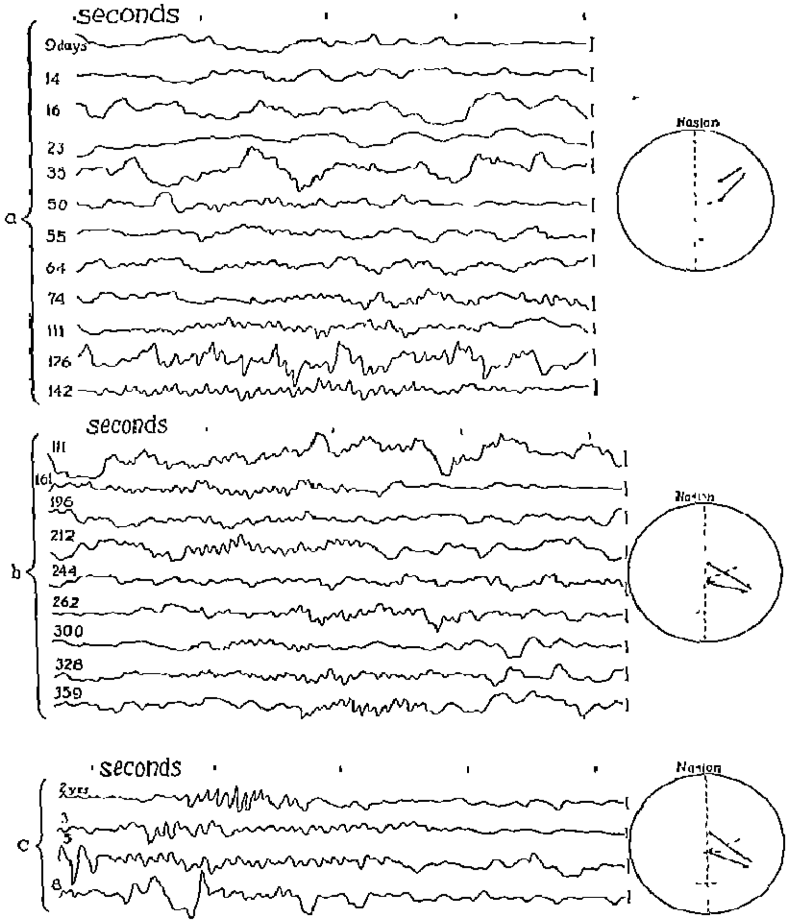

FIGURE 8

ONTOGENETIC DEVELOPMENT OF THE 12-14 PER SECOND WAVES FROM BIRTH TO 8 YEARS

a 9 to 142 days in infant *A N.*
b 111 to 359 days in infant *C. D*
c 2 to 8 years in various children
Pre central electrode positions shown in the schematic drawing to the right of each group of tracings
50μv calibrations

change is lacking It does not follow, however, that each of the rhythms presents a static unchangeable pattern during these months. It will be seen in the figures that noticeable fluctuations in amplitude, in sequence length, and in regularity occur To a certain extent, these latter variations may represent the dynamic inherently variable character of the rhythms. They may also reflect a process of tapering off or consolidation of the more definite growth changes observed in the earlier interval

Intensive serial observations on a number of infants beginning at birth and continuing uninterruptedly throughout the period of infancy should provide a more accurate and complete account of the nature of this early growth Such observations are now in progress It may only be said at present that a beginning serial study of five other infants tends to confirm the general growth trends outlined above. In two of these latter infants the interval of observation now includes the period from birth to five months, in the other three it begins at about four months and covers thereafter a period averaging nine months Considered individually, each of these younger infants shows during the first five months definite and progressive alterations along the lines already noted above. Conversely, each of the three older infants fails to show any consistent developmental trend in the various rhythmic sensory-motor area processes during the ensuing several months The indications are, therefore, that some time during the latter part of the first half year (probably during the interval from 4 to 6 months) the several rhythmic sensory-motor area activities attain a developmental maximum beyond which no consistent developmental trends are to be observed during the next several months.

One fundamental characteristic of the developmental process responsible for these early growth changes is the intrinsic variability of the process The growth of these various activities takes place not as a smooth incremental advance in amplitude, in regularity of the waves, and in length of sequence Rather it progresses in a variable and irregular manner, each of these properties of the rhythms advancing independently of the other properties and itself along a variable, erratic course The developmental course of any property of the rhythms, therefore, or of the total activity itself as the three properties unite to give it, provides the conception of continuous fluctuation above and below an abstract mean trend of growth

Evidence available from the beginning serial study of a number of older infants and young children, though far from complete, indicates that three of the rhythms remain unchanged during the period from 1 to 5 years Inspection of Figures 5, 7 and 8 shows these three to be the 1-3 per second "delta" waves, the intermediate 7-8 per second waves, and the faster 12-14 per second activity As may be seen in Figure 6, however, the 3½-6 per second "drowsy" waves apparently show a definite decline beyond the stage of infancy This decline is marked chiefly by a shortening of the rhythmic sequences of the waves and a correlative decrease in amplitude, rhythmicity remaining unchanged Beginning apparently during the third year, the decrease proceeds gradually thereafter until in children over five years of age this activity is noticeably less dominant than in infants and younger children. It appears, however, that these waves never become completely extinct We have noted them in the adult drowsy states (cf Figure 6*c*), and Davis, Davis, Loomis, Harvey and Hobart (7) likewise report that they appear in adults in the early stages of sleep.

Actually, in young children at any rate the regression in these waves is more apparent than real Thus, though they may repeatedly fail to show very strongly in a particular child during the ordinary sequential changes in pattern accompanying the onset of sleep (as will be shown in a later report these 3½-6 per second waves are particularly characteristic of the "drowsy period" just preceding the onset of sleep) they may be reestablished in their previous infantile and dominant form under special conditions. If, for example, one permits a young child in whom this pre-sleep activity is much attenuated to doze off and remain asleep for several minutes and then rouses him to the point where his eyes open momentarily, it is often observed that the 3½-6 per second waves come back in force for a short interval. During this interval these slow waves spread over the entire cortex though at a maximum over the sensory-motor region. An example of this phenomenon as seen in a five-year-old boy is shown in Figure 9. In this figure the *A* tracing in each instance represents the occipital pattern and the *B* tracing the post-central area pattern. The electrode positions are shown in the figure. The two top tracings (Figure 9*a*) indicate the pattern during a drowsing period just preceding the closure of the eyes The alpha waves dominate the occipital pattern while slower waves at 4 per

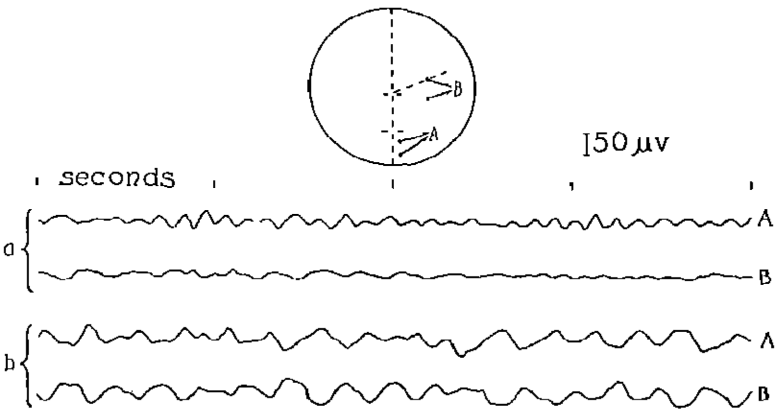

FIGURE 9

RESURGENCE OF THE 4-5 PER SECOND DROWSY WAVES AFTER PARTIAL AWAKENING

a The 4-5 per second waves appear in short attenuated series over the post-central area (Leads *B*) during the onset of sleep while the occipital area is showing alpha waves at 8½ per second (Leads *A*)

b The drowsy waves at approximately 4 per second are greatly reinforced over the post central region (Leads *B*) and spread into the occipital area as well (Leads *A*) when the child is partially awakened.

second may be seen over the post-central area. When the child was partially awakened, after he had dropped off to sleep (Figure 9*b*), the slow 4 per second waves came back greatly reinforced over the post-central region and spread over into the occipital area as well. In some children, the initial resurgence of the waves under these conditions may take the form of an unbroken sequence lasting as long as 15 to 20 seconds Thereafter, the activity fades progressively out of the picture and the previously prevailing random irregular sleep pattern is soon reestablished, though brief surges of the waves may come back intermittently for as long as several minutes. It appears, therefore, that the growth process underlying the decline of these pre-sleep drowsy waves may exhibit noticeable functional regressions which become manifest in young children under special conditions. In older children (6 years and up) we have thus far failed to observe any clear-cut resurgence of the 4 per second waves under the conditions noted above In these older children the occipital

alpha waves, which have faded out at the onset of sleep, tend to reappear when the child is partially awakened.

Thus far the writer has not attempted any restricted localization of the several individual rhythms within the sensory-motor area, although this might feasibly be undertaken by using the phase-reversal technique employed by Adrian and Yamagiwa (3) to localize the area of origin of the alpha waves. In spite of the fact, however, that all four of the rhythmic activities tend to spread over the entire sensory-motor area, a rough regional localization within this area is apparent. It is consistently observed, for example, that the small 12 to 14 per second waves are maximum in amplitude when leads are restricted to the immediate pre-rolandic area. Similarly, the intermediate 7-8 per second waves tend to be largest over the central area. On the other hand, the 1-3 per second waves and the 4-5 per second drowsy waves are usually best defined when leads are restricted to the post-rolandic area. These areas of maximum appearance of the various activities are indicated roughly by the electrode positions given in Figures 5, 6, 7 and 8.

D. Discussion

It has been observed that rhythmic electrical activity is present over the sensory-motor area of the cortex in the neonate whereas the occipital and frontal areas show "straightline" patterns at this time. Rhythmic waves do not begin to appear over the occipital area until three or four months later (19), (25), (26). These findings are in accord not only with histological and physiological evidence [Flechsig (9), Langworthy (16), (17), (18), Tilney and Kubie (27)] of comparative anatomical maturation in the occipital and sensory-motor areas, but also with behavioral data which indicate that somatic motor activity in the newborn is advanced beyond special sensory activity [Gesell (11), Shirley (24), McGraw (22)]. The fact that various synchronous waves are well defined over the sensory-motor area in older infants in whom this area of the cortex is certainly functioning, whereas these same waves are present in the newborn only in immature form, suggests that in the neonate they may be indicative of emerging sensory-motor cortical function. On the other hand, the synchronous waves may be merely anticipatory of the emergence of function in the sensory-motor cortex and the actual functional participation of this cortical system in behavior

may be delayed for some time. Regardless of their relation to the functional capacity of the cortex, the various motor area waves would seem to have their origin in utero since they may be detected at birth. In this connection it is interesting to note that Jasper, Bridgman, and Carmichael (13) have observed rhythmic electrical activity over the cortex of the fetal guinea pig as early as two weeks before term. They recorded directly from the dura in the parieto-occipital region. Kornmueller (14) had previously reported that he was unable to detect any cortical potentials until 6 days after birth in the rabbit.

One of the conspicuous properties of nervous centers (Adrian 1, 2), is the tendency for large groups of neurons to beat together rhythmically when undisturbed by afferent excitation Under these conditions of rest the spontaneous discharges of individual neurons presumably get into step through mutual facilitation, and large synchronized waves are thereby produced Such a mechanism, operating presumably within the occipital grey matter, is suggested by Adrian and Yamagiwa (3) as the basis of the adult human alpha waves The abolishment of the waves under conditions of visual stimulation is further suggested as being due to the fact that incoming sensory impulses alter the rate of discharge in the individual cells, forcing them to discharge at different rates and thereby disrupting the previous synchronized beat The writer's findings might be interpreted as indicating that such a mechanism is beginning to be operative in the sensory-motor cortex at birth It will be recalled that the sensory-motor area waves appear in the newborn only when the infant is relaxed and asleep and at a time, therefore, when the sensory-motor cortex would be assumed to be relatively free from sensory somatic excitation Assuming that groups of neurons within this region might begin to discharge spontaneously in unison under these conditions, then subsequent abolishment when the infant awakens and moves would be understandable in terms of the mechanism proposed by Adrian and Yamagiwa for the alpha waves Waking and moving would be accompanied by an influx of sensory excitation into the sensory-motor system which supposedly would break up the resting synchronized discharge as noted above, and instead of the larger summated waves the low-voltage potentials of the now asynchronously discharging cells would appear

As they appear in the neonate, the several spontaneous rhythmic

waves are both small in amplitude and brief in rhythmic sequence when compared with these same waves as observed in older infants. In line with the previous assumptions concerning the nature of the various waves as due to the synchronized summated discharge of many individual cells, these findings might suggest that in the beginning stages of their development comparatively fewer individual units are contributing to the spontaneous synchronous discharge than in later more mature stages. The growth of the several rhythms, particularly the overall increase in the amplitude of the waves, might then appear to involve as one factor an increase in the number of cortical neurons available for spontaneous rhythmic discharge under proper conditions of lack of afferent disturbance in the sensory-motor area. Certain observations relative to the sensory-motor area waves offer suggestive evidence in this connection. If two pairs of leads are placed over the sensory-motor area in the newborn, separated by only 2 or 3 cms (cf Figure 2*a* above), the recurrent brief bursts of any of the rhythmic waves rarely appear under both pairs of electrodes simultaneously. Rather, first one and then the other set of leads picks up the waves as the apparently circumscribed locus of activity shifts under one and then the other pair of electrodes. In older infants, on the other hand, the waves are not only greater in amplitude and longer in synchronous sequence, but they are observed simultaneously over larger areas. Instead of the intermittent low-amplitude synchronous discharge of seemingly isolated small areas, one now observes a persistent dominant rhythmic beating apparently occupying a much larger region of tissue. In some infants indeed it often appears that the entire sensory-motor system is beating as a single unit, and the rhythmic waves are observed to spread over the entire cortex in uniform dominant series. The very slow delta waves and the 4-5 per second drowsy waves are particularly apt to exhibit this large dominant type of activity.

Mere increase in the number of rhythmically discharging cells would not alone account for the greater persistence of the waves, that is, for the increased length of rhythmic sequence. One has to assume in addition either that the tributary discharge of the individual neurons becomes more persistent during development so that the summated waves appear in longer series, or that the individual cells may participate at alternate intervals in the grouped discharge, thereby producing a comparable effect. Possibly both of these factors are involved in the growth of the rhythms.

The presence of several rhythmic activities over the sensory-motor cortex raises the question as to the locus of origin of the individual rhythms within this system. It has been noted that there is an apparent rough regional localization within this area, the 12-14 per second waves tending to be at a maximum over the pre-rolandic area and the 7-8 per second waves over the central region, while the very slow delta waves and the 3½-6 per second drowsy activity are similarly at a peak over the post-central area. Any definite assumptions as to a more restricted areal localization within the sensory-motor system or as to the particular cell groups involved in the production of the individual rhythms cannot be proposed. It does appear that the various waves are too diffusely spread over the sensory-motor cortex to have their origin within any single restricted cyto-architectonic field. Observations by Dusser de Barenne and McCulloch (8) on monkeys indicate the dependence of cortical potentials within a given local area upon different cell layers. One possibility is that the individual rhythms observed over the sensory-motor area in infants may be associated with different cortical layers.

E. Summary

Observations in a beginning longitudinal study of the electroencephalogram during normal infancy and childhood have been presented. Several general findings may be noted.

Rhythmic electrical activity is present over the sensory-motor area at birth, whereas occipital and frontal areas show "baseline" patterns. The activity in question ranges in frequency from 1 to approximately 20 cycles per second and includes 4 apparently distinct frequency bands (1-3 per second "delta" waves, 3½-6 per second "drowsy" waves, 7-8 per second intermediate waves, and 12-14 per second waves [Loomis, Harvey, and Hobart "spindles"]). These waves are present only during sleep, they are abolished when the infant wakens. During subsequent development, these waves increase in amplitude and in length of rhythmic sequence and improve in regularity, apparently reaching a peak at 4-6 months. Thereafter three of the rhythms (1-3, 7-8, and 12-14 per second) remain unchanged. The 3½-6 per second "drowsy" waves show an apparent decline in amplitude and length of rhythmic sequence noticeable from three years on.

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THE ELECTROENCEPHALOGRAM DURING NORMAL INFANCY AND CHILDHOOD: II. THE NATURE OF THE GROWTH OF THE ALPHA WAVES*

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J ROY SMITH

A INTRODUCTION

Berger (4) was the first investigator to show that the so-called alpha waves of the electroencephalogram (*e e g.*) are slower in children than in adults Lindsley's (13) more recent data and those of the writer (19) have served to supplement Berger's original observations and to establish the overall trend of the frequency growth of these waves during infancy and childhood. Davis and Davis (5), Kreezer (12), and Loomis, Harvey, and Hobart (15) have also reported slower frequencies in normal children than in adults

Additional evidence is offered in the present paper concerning the nature of the growth of the alpha waves Tracings have been obtained from 63 normal children Included in this total were 17 infants and young children, up to five years of age upon whom serial observations were made over periods varying from 4 to 18 months. Supplementary cross-sectional data were obtained from single observations upon a group of 46 older children ranging in age from 3 to 17 years. Other rhythmic electrical activities of the *e.e g*, observed in these same children, have been described in a previous report (20) The reader is referred to the latter paper for a description of the technique and conditions of observation governing the present findings.

B. RESULTS

It was pointed out in earlier reports (19), (20) that while rhythmic electrical waves may be demonstrated over the sensory-motor area in the newborn infant, the occipital lobes show a flat "baseline" pattern. During the first 3 months after birth the bulk of the activity observed in the *e e g* continues to be restricted to leads

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placed over the sensory-motor area. The occipital pattern remains throughout this interval typically low-level and random in appearance. Brief sequences of irregular potentials of alpha magnitude (50 μv approximately) may be observed occasionally during the second and third months, but it is not until the end of the third month that short series of rhythmic waves varying between 3 and 4 per second begin to appear over this area.

Repeated observations on the same child show that when these occipital[1] waves first begin to emerge they are quite variable in appearance, being well defined one week and hardly noticeable the next. By the end of the fifth month, however, they are usually well established and recur consistently. Thereafter, their development is quite comparable to that of the various antecedent sensory-motor area activities previously described. In addition to changes in amplitude, regularity, and length of rhythmic sequence, these waves also show a progressive increase in frequency over a period of several years.

During the first few months of their development, the positive identification of the occipital waves is often rendered difficult by the simultaneous presence of the antecedent 3½-6 per second sensory-motor region drowsy waves. It often happens for example that two pairs of leads placed over occipital and sensory-motor areas respectively show simultaneously rhythmic waves at 4 to 5 per second and almost identical in appearance. It is then impossible to determine whether these waves represent occipital activity spreading into the sensory-motor region or vice versa or whether both activities are simultaneously present. Fortunately, it is possible to avoid this difficulty to some extent by careful control and observation of the infant. If one records continuously as the child regresses from an "awake" condition (eyes open, vocalizing perhaps, and moving intermittently) through a state of "drowsiness" (eyes beginning to droop, more re-

[1]It should be noted that employing a restricted bi-polar technique, as has been done in the present study, the alpha waves have consistently been observed to be maximum in amplitude and most persistent in appearance when leads were confined to the occipital area, or when one lead was placed over this region and the other just outside, as for example, over the superior parietal region. This general finding is in harmony with observations on the adult rhythm by other investigators [Adrian and Matthews (2), Adrian and Yamagiwa (3), Davis and Estes (5), Jasper and Andrews (10) and others].

laxed), to a condition of "sleep" (complete relaxation, eyes closed, breathing regularly) it is usually observed that the occipital waves take precedence during the initial "awake" period, being well defined, while waves of similar frequency are either absent over the sensory-motor area or less well defined As the child begins to drowse and his eyes begin to droop, however, similar waves at 4 to 5 per second appear in force over the sensory-motor area and both regions may now show this activity until after the onset of sleep

In order, therefore, to eliminate as far as possible this interference from the sensory-motor region waves, it has been attempted to record the alpha waves consistently under optimum "awake" conditions, that is during an initial period definitely preceding the drowsing period which in turn immediately precedes closure of the eyes and the onset of sleep As the child grows older, it becomes easier to segregate the initial "awake" interval from the drowsy state which precedes sleep and consequently easier to correctly segregate the alpha rhythm Identification of course becomes even more certain once the alpha frequency has progressed to a level beyond the frequency limits of the interfering sensory-motor region activities. This level is reached at 6 to 6½ cycles per second anywhere from 12 to 15 months of age The interval of greatest frequency overlap of the two activities and consequently of greatest difficulty is from 6 to 12 months of age when the alpha frequency is progressing from approximately 4½ to 6 oscillations per second

Some indication of the nature of the early development of the alpha waves is given in Figure 1 and Figure 2 In Figure 1 is shown the

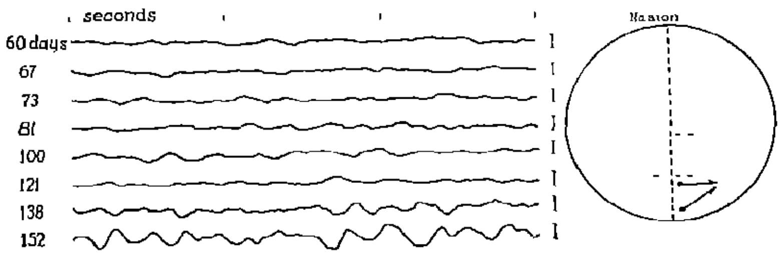

FIGURE 1

EMERGENCE OF THE ALPHA WAVES AS SEEN IN INFANT *B M.* ELECTRODE POSITIONS INDICATED AT THE RIGHT.

50 μv calibrations

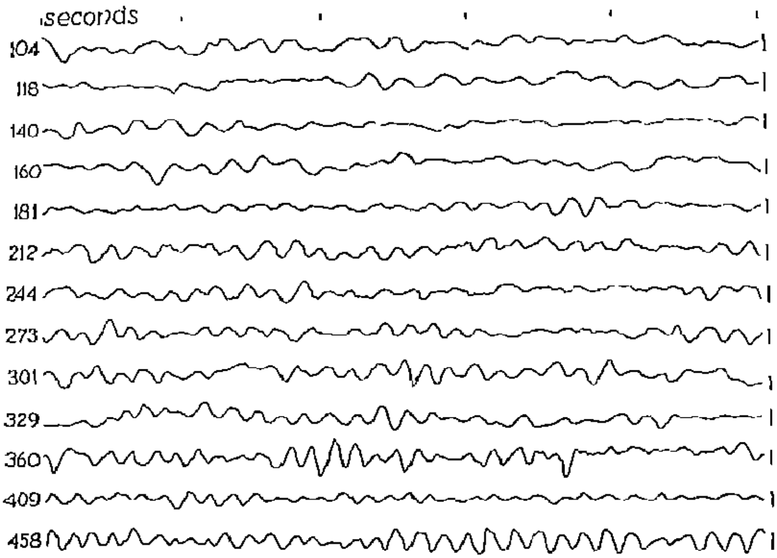

FIGURE 2
DEVELOPMENT OF THE ALPHA WAVES FROM 3½ TO 15 MONTHS IN INFANT P D
Electrode positions as in Figure 1. 50 μv calibrations

emergence of this activity as it occurred in one infant. Absent at 60 and 67 days, the waves are beginning to show above the baseline at 73 days in brief sequences of two or three oscillations at 3 to 4 per second At 81 and 100 days, they are fairly well defined, at 121 days, they have regressed again and can barely be detected. Finally at 138 and 152 days, they are well under way at approximately 4 per second.

The further development of the waves during the period from 3½ to 15 months in another child (baby *P.D.*, Table 1 below) is indicated in Figure 2. Serial observations began on this child at 104 days, at which time the alpha waves were clearly in evidence at about 3 5 per second. During the next 12 months, as may be seen in the figure, the waves increased gradually in frequency to a level of about 6.5 cycles per second Correlatively with this increase one may observe an improvement in the regularity, a lengthening of the

rhythmic sequences and a tendency for the waves to be maintained at uniform higher amplitudes. With the exception of the progressive increase in frequency, these various growth changes are basically similar to the trends and sequences noted earlier (20) for the several sensory-motor area activities.

Further data indicating the manner in which the frequency increases with age are presented in Tables 1 and 2. Included in Table 1 are serial observations on a group of 11 infants and young children For the infants under 18 months of age, the monthly frequencies given in this table are based upon observations covering usually the last week in each month and the first week in the following month The monthly frequencies beyond 18 months were determined on the basis of single observations at the end of each month. Similarly, the rates presented for the older children in the table were determined on the basis of single observations at the half-yearly intervals indicated For the individuals of each group, the complete range of frequencies observed at each age level is presented and the average frequency is indicated as the mid-point of this range Justification for this latter procedure lies in the fact that the frequencies observed were consistently spread uniformly over the ranges indicated In order to determine the distribution and range of frequencies at each age level, the individual's occipital tracings were gone over systematically and the alpha wave frequency was measured in successive bursts of the rhythm All measurements were made in accordance with criteria established previously (20) for the sensory-motor area rhythms, namely that there must occur in sequence three or more regular waves having a minimum amplitude of 10 μv. Except during the very beginning of the alpha development, the limits set by these criteria were rarely encountered and it was possible to determine frequencies successively on the basis of well-defined rhythmic series averaging 6 or more waves.

In Table 2 are presented grouped data on 46 older children ranging in age from 3 to 17 years Average frequencies were determined here for each child on the basis of single observations and these averages were then grouped at each yearly age level to provide the ranges and averages indicated in the table. The frequency range and average frequency determinations from observations on 15 adults are also presented in Table 2 All of the tracings upon

TABLE 1

FREQUENCY VARIATION OF ALPHA WAVES WITH AGE: SERIAL OBSERVATIONS ON THE SAME CHILD

The frequency ranges and average frequencies in oscillations per second are given for each age

	Subject											
Age	*B.M.*	*E.W.*	*P.D.*	*C.D.*	*R.L.*	*E.D.*	Age	*A.R.*	*D.L.*	*Jo.W.*	*J.W.*	*A.D.*
3 mo	3.3 3.7 4.0	4.0 4.1 4.2	3.5 4.0 4.5	3.5 4.0 4.5	3.0 3.3 3.5		14 mo	6.8 7.0 7.1				
4 mo	3.5 3.8 4.0	3.5 4.0 4.5	3.5 4.0 4.5	3.5 4.0 4.5	3.0 3.3 3.5		15 mo	6.8 6.9 7.0				
5 mo	4.3 4.7 5.0	3.5 4.3 5.0	4.0 4.6 5.2	4.5 4.8 5.0	3.5 4.0 4.5		16 mo	6.9 7.1 7.2				
6 mo	4.6 5.3 6.0	4.5 4.8 5.0	5.0 5.1 5.2	5.0 5.1 5.2	4.0 4.3 4.5	4.5 4.8 5.0	17 mo	7.0 7.3 7.5				
7 mo	5.0 5.6 6.2	4.7 5.1 5.5	5.0 5.7 6.3	5.0 5.3 5.6	4.5 5.0 5.5	5.0 5.2 5.3	18 mo	6.8 7.3 7.8				
8 mo	5.0 5.6 6.2	5.4 5.9 6.4	4.8 5.3 5.7	5.3 5.5 5.6	4.5 5.2 5.8	5.3 5.5 5.7	19 mo	7.2 7.8 8.4				
9 mo.	5.5 6.0 6.4	5.5 5.9 6.3	5.2 5.5 5.7	5.3 5.9 6.4	5.8 5.9 6.0	5.0 5.8 6.5	20 mo	7.5 7.9 8.3				
10 mo		5.8 6.2 6.5	5.2 5.8 6.4	5.4 5.8 6.1	5.8 5.9 6.0	5.5 6.2 6.8	21 mo	7.3 7.7 8.0				
11 mo		5.3 6.0 6.7	5.2 5.8 6.4	5.6 6.1 6.6	5.7 6.0 6.3	6.0 6.3 6.5	22 mo	7.5 7.9 8.2				

TABLE 1 (*continued*)

Subject

Age	B M	E W	P D	C D	R L	E D	Age	A R	D L	Jo W	J W.	A D
12 mo		61 66 70	55 63 70	56 62 67	60 62 63	60 63 66	24 mo	74 78 82				
13 mo			60 64 68	59 62 65	62 64 66	62 67 71	25 mo	78 81 84				
14 mo			62 65 68		58 66 73	6.2 67 72	2½ yrs		70 75 80			
15 mo			60 66 71	55 62 69	65 71 78	66 70 74	3 yrs		78 81 84			
16 mo			58 64 69	60 6.4 68	62 69 75	66 71 76	3½ yrs		76 82 8.7			
17 mo					63 69 72	65 70 74	4 yrs			80 85 90	80 8.3 86	79 81 83
18 mo					64 70 76	69 72 74	4½ yrs			87 8.9 90	80 8.4 87	77 81 85
19mo					66 72 77	70 74 77	5 yrs			88 9.2 96		
20 mo					65 71 76							

TABLE 2

FREQUENCY VARIATION OF ALPHA WAVES WITH AGE GROUPED DATA ON OLDER CHILDREN BASED ON SINGLE RUNS ON EACH CHILD

No. of subjects	Age in years	Frequency range (oscillations per second)	Average frequency (oscillations per second)
3	3	8.0- 8.9	8.3
3	4	8.1- 8.5	8.3
2	5	8.8- 9.4	9.1
4	6	8.0- 9.0	8.6
3	7	8.0- 9.5	8.7
5	8	8.3-10.0	9.2
3	9	8.4- 9.5	9.0
5	10	8.0- 9.9	9.1
2	11	9.0- 9.0	9.0
3	12	9.0- 9.6	9.2
4	13	8.8-10.0	9.7
3	14	8.2-10.0	9.2
2	15	9.9-10.3	10.1
2	16	9.1- 9.3	9.2
2	17	10.5-11.2	10.9
15	19-32	8.5-11.5	10.2

which the data of these two tables are based were obtained under apparently "awake" conditions as outlined above.

If one follows the course of the frequency growth of the alpha waves as indicated in Tables 1 and 2, it is observed that this growth shows an initial phase of rapid increase followed by a gradual tapering off toward a maximum adult level. These waves appear at about 3½ oscillations per second at 3 months. During the next 15 months, they progress to a level of approximately 7 per second. Thereafter, the rate of increase slows down and the adult level of 9 per second is not established until perhaps 8 years.

The nature of this growth is indicated more clearly in Figure 3, in which the serial observations of Table 1 are represented by the densely overlapping band of data covering the first two years on the age axis and by the various succeeding symbols extending over the interval from 2½ to 5 years. Average monthly frequencies are plotted for the infants and semi-annual rates for the older children. The succeeding trend of larger open circles represents the cross-sectional data of Table 2. Also included for comparison are the recent cross-sectional observations of Lindsley (13) indicated by the solid black circles and extending from 4 months to 15 years.

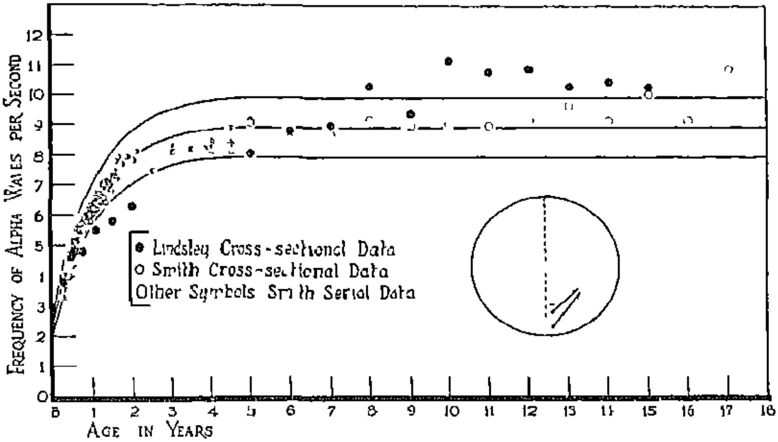

FIGURE 3

FREQUENCY GROWTH OF THE ALPHA WAVES FROM 3 MONTHS TO 18 YEARS, SERIAL AND CROSS-SECTIONAL OBSERVATIONS

Cf. explanation in text.

The three smooth curves shown in Figure 3 represent an approximate empirical fit to the overall trend of the writer's data based on the general assumption that the frequency growth of the alpha waves might be exponential in form. The individual curves of the envelope are identical in form and were derived from the exponential relation recently suggested by Weinbach (21)

$$f = fm - Be^{-KA}$$

In this equation "f" represents the measured alpha wave frequency, and "fm" the maximum adult frequency, "B" is a constant having the dimensions of frequency (ordinate intercept constant), "K" is a constant indicating the rate of decline of the increase in frequency with age, and "e" is the base of the natural logarithms.

The writer's observations are seen to follow fairly consistently a mean exponential trend approaching a pre-adolescent maximum of 9 cycles per second. Beyond the pre-adolescent period and beginning at 12 years, the observations rise definitely above this 9-cycle maximum. This latter rise in frequency might suggest some relation to the onset of adolescence. It should be noted that

Lindsley's observations show a comparable acceleration in frequency during the immediate pre-adolescent period As shown in Figure 3 this rise in rate is more marked than that shown by our data and appears two years earlier at 10 years. Qualitatively, therefore, the data are indicative of acceleration in the alpha wave frequency associated in some manner with the onset of adolescence More abundant observations on larger numbers of children at each age level will be required, however, to establish the magnitude of the process and its relations in time to those phases of the alpha frequency growth which precede and follow it

In addition to showing consistently higher frequencies during the pre-adolescent period, Lindsley's data also tend to show a less rapid rate of increase in frequency during the first two years Here again more numerous observations will be needed to determine the range of variability for the beginning slope of the alpha growth process. The consistency shown by the writer's intensive serial observations during this period is suggestive, but is thus far based on observations on only a few infants

If continued serial observations show an exponential relation of the type described above to fit the course of the alpha frequency development for each child, then it will be of interest to determine whether or not the constant *K*, representing the rate of decline of the frequency increase with age, is characteristic of the individual Weinbach has suggested the possibility of such a growth constant The exponential curve in question has been fitted tentatively to the individual serial data of Table 1 and apparently significant differences in the constant *K* have resulted Three of these beginning segments of the alpha frequency growth process are shown in Figure 4 For these three infants, *K* varies as shown for the fitted curves between .042 and 060, where these values are proportional to per cent decline per month of the increase in alpha wave frequency Values of *K* for the other infants range from .05 to .066.

The curves shown for babies *E D* and *R L* in Figure 4 were fitted when the data were available for only the first 12 months of life in an effort to predict the succeeding alpha frequency values It is seen that the predicted values agree with the observed values up to the age of 17 months in the case of *E D* and 16 months for *R.L.* At these age levels both infants then show definite regression below the predicted curves, following which the frequencies again rise

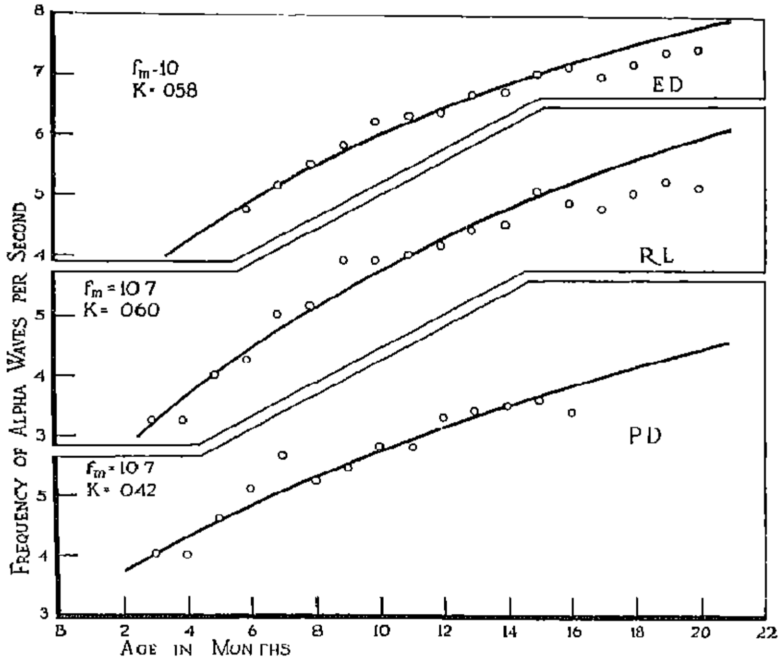

FIGURE 4

INDIVIDUAL ALPHA WAVE FREQUENCY GROWTH CURVES FOR THREE INFANTS

The constant K of the fitted exponential curves indicating the time rate of decline of the increase in frequency with age is given for each child The value of the assumed maximum frequency (*fm*) is also indicated for each child.

during the next several months. The data are not yet complete enough for either child to indicate whether this shift below the curve represents only a temporary deviation away from the overall growth trend or whether it might represent the beginning of a second developmental trend which will proceed possibly at a different time rate of decline (K) toward the adult maximum

The writer has thus far not attempted to determine systematically the conditions under which the alpha waves may be abolished However, the waves in the infant or young child are qualitatively similar to the adult waves in their particular susceptibility to suppression by

visual stimuli. This was best indicated by the fact that the waves appeared optimally only when the child was kept in the dark. If a light was turned on in the room while the waves were appearing, they were promptly suppressed. They might begin to come back under conditions of continued illumination but were consistently less dominant and persistent Conversely they were promptly reinforced when the light was turned off and the room was again thrown into darkness.

In respect to their abolishment by other types of stimuli, the waves also appear to be comparable to the adult waves. They may be suppressed, for example, by a sudden loud noise, by calling the child's name, or by a light pin prick on the arm or leg It appears, however, that extra-visual stimuli are less consistent in suppressing the waves and are effective in proportion to their startle value.

C Discussion

It was suggested in a previous report (20) that the presence of rhythmic waves over the sensory-motor area of the brain at birth might be indicative of the emergence of function in the cortical sensory-motor system, since these same waves are better defined in older infants in whom this area is certainly functioning. It would also appear reasonable to assume that the emergence of the alpha waves at 3 or 4 months over the occipital lobes is correlated with the onset of function in the cortical visual mechanism. This latter inference is based upon the fact that the appearance of the alpha waves corresponds with other possible indices of beginning cortical vision. At three or four months, for example, the first suggestive indications of reaching prehension behavior are just beginning to be noted [McGraw (16), Gesell (6, 7), Shirley (18)].

In several respects (overall increase in amplitude, lengthening of rhythmic sequence, improvement in regularity) the growth of the alpha waves is basically similar to the growth of the sensory-motor area rhythms (20) The distinguishing characteristic of the growth of the alpha waves however, not shown by the sensory-motor area rhythms, is their progressive increase in frequency during the first 8 or 10 years. Thus far, there is available no direct evidence indicating the controlling physiological factors underlying this frequency increase with age. Certain recent evidence however relative to the

adult alpha waves appears to be of some significance in this connection. Hoagland and his associates [Hoagland (8), Hoagland, Rubin, and Cameron (9), Rubin, Cohen, and Hoagland (17)] have suggested that the adult alpha rhythm is directly determined by the local respiration of cells in the occipital cortex and that the frequency of the waves is proportional to the rate of this metabolic activity. This general conclusion is based upon several sets of mutually consistent observations, namely: (*a*) the correspondence of the temperature characteristics (μ) for the alpha wave frequencies with the principal ones for cell respiration in vitro (8), (*b*) the significant lowering of the alpha frequency during hypoglycemia induced by insulin and its restoration after injection of glucose (9), and (*c*) the effect of artificially induced hyperthyroidism in increasing the alpha wave frequency (17).) It should also be noted that Jasper (11) confirmed Hoagland's μ of 8,000 calories for normal subjects. In addition Lindsley and Rubenstein (14) obtained a rank difference correlation of 903 between alpha frequency and metabolic rate (total calories per hour) in 13 adult subjects They suggest that metabolic rate is a controlling factor in determining the differences observed in the adult frequency and that it may also be significant with respect to the variations in rate observed in children. Granting that changes produced in the adult alpha frequency might be explained in terms of altered local respiratory metabolism in occipital cortical neurons producing the waves, it would appear that corresponding metabolic changes might be involved as one factor at least in determining the frequency growth of the waves in children. Other factors of course of which we have as yet no evidence might well be involved.

A possible objection to the acceptance of any such hypothesis would be the failure of the several sensory-motor area rhythms to show any increase in frequency during growth. It might be, however, that the probably phyletically older sensory-motor area rhythms have a different physiological pacemaking mechanism which attains functional maturity earlier in ontogenesis (at birth) and does not alter significantly thereafter If this were true any increase in the frequency of the waves corresponding to the alpha frequency increase might not be expected

One point of view concerning the alpha waves [Adrian (1), Adrian and Matthews (2), Adrian and Yamagiwa (3)] assumes

that they are composed of the summated synchronized discharge of many individual cells The waves therefore supposedly reflect the corresponding unit discharges of the individual cells If this hypothesis is accepted, the frequency growth of the waves would then seem to reflect a corresponding alteration in the spontaneous rhythmic properties of the individual neurons.

D. Summary

The alpha waves appear over the occipital lobes at 3 or 4 months with a frequency of 3 to 4 per second Thereafter they increase gradually in frequency, the adult level of 9 cycles per second being established at about 8 years This frequency growth may be described empirically by an exponential equation, and there is some indication that the time rate of decline of the frequency increase with age is characteristic of the individual Along with the frequency growth, the alpha waves also increase in amplitude and in length of synchronous sequence and improve in regularity.

Certain theoretical implications of the findings have been discussed.

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THE ELECTROENCEPHALOGRAM DURING NORMAL INFANCY AND CHILDHOOD. III PRELIMINARY OBSERVATIONS ON THE PATTERN SEQUENCE DURING SLEEP*

Normal Child Development Study of the Department of the Diseases of Children, Columbia University, and the Babies Hospital, New York City

J ROY SMITH

A INTRODUCTION

If one records the electroencephalogram of an infant or young child while he regresses from a waking condition through a state of drowsing into sleep, the pattern of the electrical activity is observed to undergo marked alteration This alteration is sufficiently systematic and reproducible from one child to another to enable one to speak of a typical "awake-asleep pattern sequence." The sequence in general proceeds in such a way that various rhythmic waves succeed each other in the pattern each in turn more or less dominating the activity Several of these latter rhythmic waves have already been described and the growth changes undergone by them during infancy and early childhood have been outlined (5, 6, 7) It is the purpose of the present paper to consider in preliminary fashion the developmental changes manifest by the awake-asleep sequence itself during the same period This will involve the description and comparison of the sequence at different age levels during the first five years of life

The findings upon which the report is based have resulted chiefly from serial observations on a group of 15 normal infants and young children extending over a period of 18 months For a description of technique and conditions of observation, see an earlier report (6).

B RESULTS

In the newborn infant, a consistent pattern sequence accompanying the onset and course of sleep may be observed Roughly two stages in this sequence may be distinguished If the infant is *"awake"*

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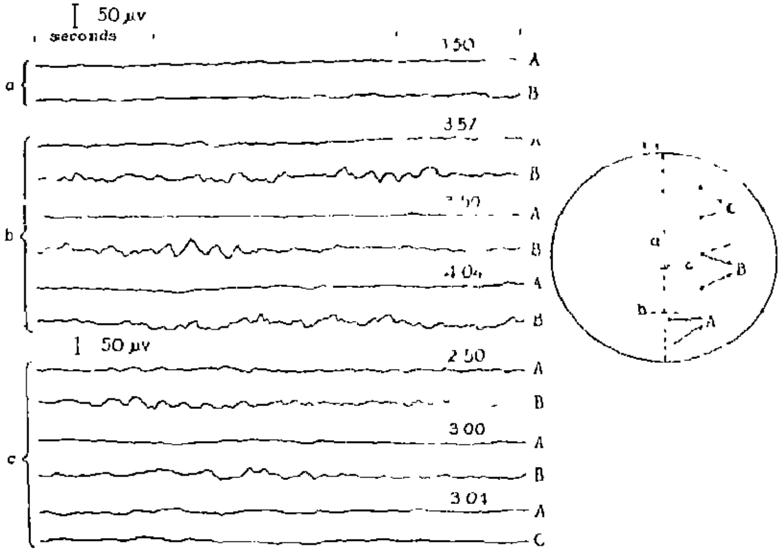

FIGURE 1

THE *e e g* IN A NEONATE DURING WAKING AND SLEEPING

a Typical awake "baseline" tracings at 4 days

b Rhythmic waves appearing over post-central area (leads *B*) after onset of sleep in the same infant Prevailing frequencies 1-5 per second, though waves at 8 per second also appear. Occipital pattern remains "baseline"

c Sleep patterns observed in same infant at 11 days Note small waves at 15 per second (leads *B*, 2 50 p m) and very slow waves at 2½ per second (leads *B*, 3 30 p.m.) Occipital (*A*) and frontal (*C*) tracings are "baseline" Electrode positions shown in approximate relation to cortical structures in the schematic drawing at the right. Leads *A* occipital along the midline (*a*), anterior lead just posterior to the lambda (*b*) and interelectrode distance 3½ cm Leads *B* post-central, anterior lead approximately over the central sulcus (*c*), other lead 4½ cm directly posterior Leads *C* frontal, posterior lead 4½ cm directly anterior to anterior "*B*" lead and interelectrode distance 4 cm *B* and *C* leads 4 cm to the right of the midline

in the ordinary sense of the word (i e , eyes wide open, moving intermittently, and perhaps vocalizing occasionally), leads taken from any area exhibit typically low-voltage, "baseline" patterns. After the child's eyes close and he is lying quiet, apparently *"asleep,"* leads restricted to the sensory-motor region show an increased level of potential while occipital and frontal patterns remain at their pre-

vious baseline level The pattern appearing over the sensory-motor area during this asleep phase is predominantly random or irregular. It is characterized, however, by the occasional appearance of various rhythmic waves which are to be seen in short sequences segregated momentarily against the prevailing random background (cf. Figure 1) As thus far observed, these waves vary in frequency from one to *approximately 20 per second They may be classified (6) within* four apparently distinct frequency bands (*a*) 1-3 per second "delta" waves, (*b*) 3½-6 per second "drowsy" waves, (*c*) 7-8 per second waves and (*d*) 12-14 per second (sometimes 19-20 per second) waves [Loomis, Harvey and Hobart "spindles" (4)].

Within the newborn sleep stage our observations thus far fail to show any systematic sequential differentiation of these several rhythmic activities such as occurs in older infants. There appears to be some tendency for the faster 12-14 per second waves to be delayed until after the slower rhythms have been coming through for some minutes, but this finding will have to be substantiated by further observations Typically the several rhythmic activities appear erratically one after the other or mixed together in random fashion.

During the first few months of post-natal life, noticeable changes occur in the organization of the awake-asleep pattern sequence. The prevailing 3½-6 per second waves of the newborn sleep stage gradually tend to become shunted forward in sequence to occupy characteristically a pre-sleep drowsing period. Correlatively, the slower 1-3 per second delta waves are shifted further back in the sequence and are usually observed now in what appears to be deep sleep. The 12-14 per second waves meanwhile have assumed an intermediate position between these two activities. As may be seen in Figure 2*a*, this essential sequential arrangement of the several sensory-motor rhythms may be established as early as three months after birth and before the appearance of the occipital alpha waves.

Once the alpha waves are established (usually by the end of the fifth month) they occupy an initial or waking phase in the sequence preceding the serial appearance of the several sensory-motor rhythms. For some months following the appearance of the latter waves, however, this initial awake alpha wave stage is usually not recorded in its full extent because the infant tends to drowse off too soon after quieting down sufficiently for tracing to be taken In spite

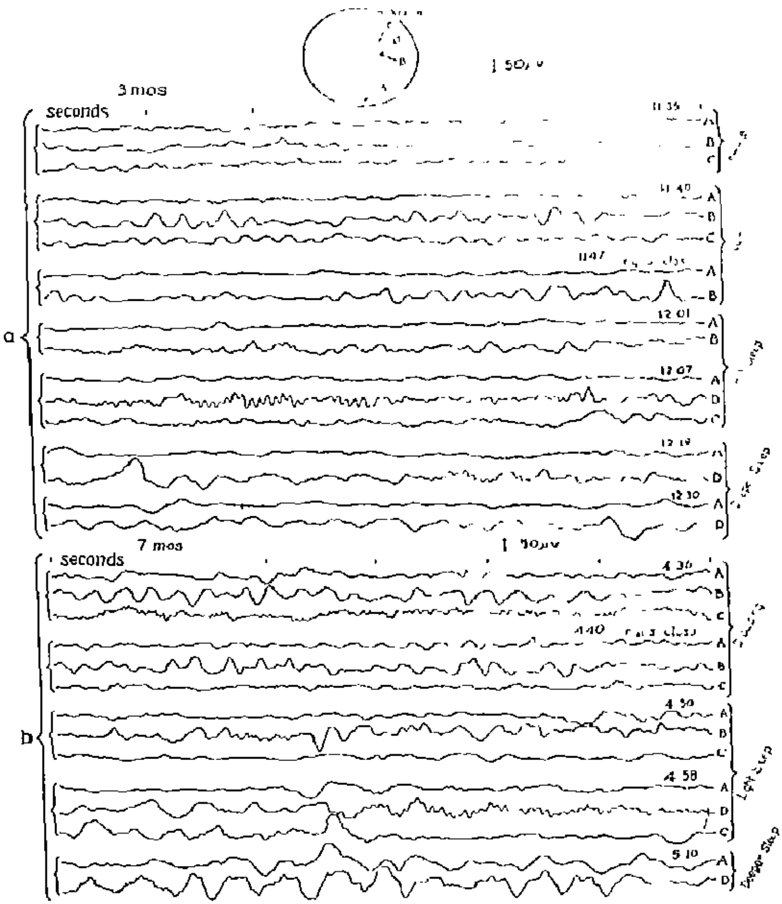

FIGURE 2

ALTERATION IN THE PATTERN OF THE *e e g* DURING SLEEP

a Baby *T.H* at 3 months
b. Baby *T L* at 7 months
Cf explanation in text.
Electrode positions, Leads *A* (occipital), *B* (post-central) and *C* (frontal) as in Figure 1 Pre-central leads (*D*) are common with anterior *B* lead and posterior *C* leads.
The third tracing shown in several groups (leads *C*) represents the frontal pattern taken about 30 seconds after the preceding occipital and sensory-motor area tracings The small fast irregular waves observed in the frontal pattern [(leads *C*) top group of tracings, Figure 2*b* particularly] are muscle action potentials

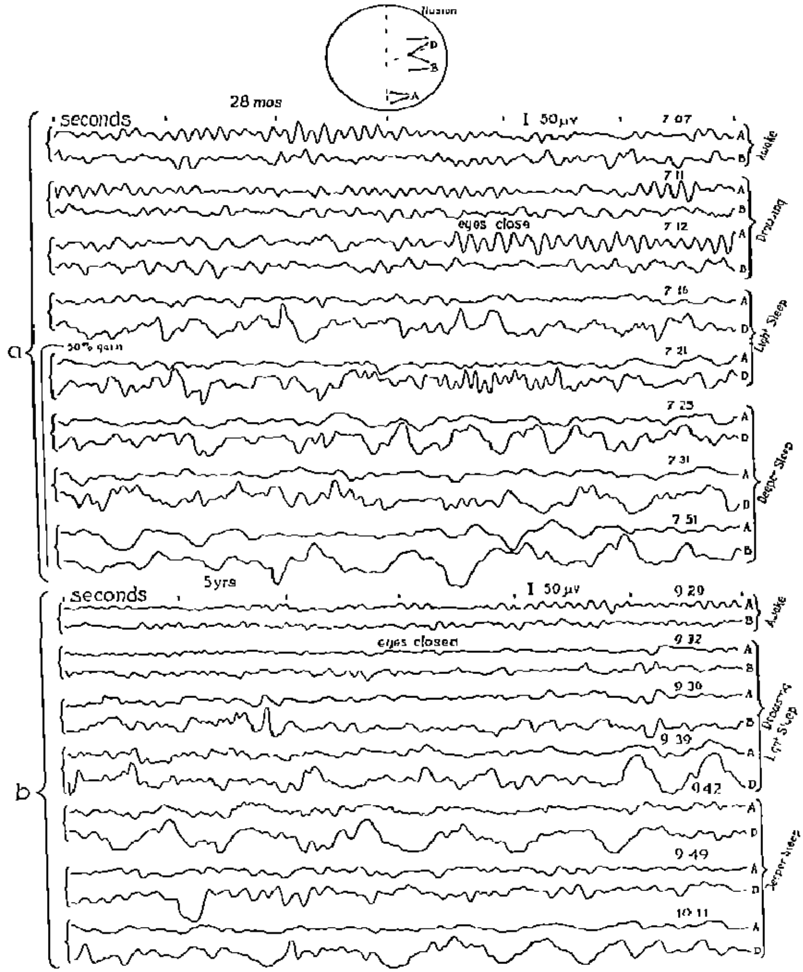

FIGURE 3

Alteration in the Pattern of the *e e g* during Sleep

a *A R* at 28 months
b *A D* at 5 years
Cf explanation in text
Electrode positions as in Figure 2

of the fact, therefore, that the infantile pattern sequence is now potentially complete and essentially comparable to that of an older child (cf Figure 3*a*), as recorded it is usually somewhat foreshortened through the restriction of the awake alpha wave stage. The sequence of the 7 months' old child shown in Figure 2*b* is typical. In this child the alpha waves are seen to appear only briefly at about 5 per second over the occipital area (leads *A*). They are already overshadowed by the larger slower waves at 3½-4 per second appearing simultaneously over the post-central region (leads *B*).

Considered in detail the infantile sequence at the time of the early development of the alpha waves proceeds somewhat as follows: With the infant lying awake and quiet (eyes open, alert) the alpha waves may appear over the occipital area for a short time before any well-defined activity has begun to show over the sensory-motor region. Often, however, as noted in Figure 2*b*, this initial alpha phase is less well-defined and the sensory-motor area will already show beginning sequences of drowsy waves at about 4 per second in company with the occipital alpha waves As the child begins to drowse and his eyes start to droop, these slow waves tend to be reinforced over the sensory-motor region, usually reaching their peak just as the eyes close The occipital alpha waves have meanwhile usually faded out and from this time on the sensory-motor area activities dominate the pattern sequence After the eyes close[1] the series of the large slow drowsy waves become progressively shorter and less regular although this activity continues to stand out in the sensory-motor region pattern for a period of minutes Eventually short sequences of small waves at 12 to 14 per second begin to appear in association with the irregular drowsy waves These latter waves are then reinforced gradually over a period of minutes as the slower drowsy waves fade further from the pattern. When they have

[1]Just where in this sequence wakefulness leaves off and "sleep" begins cannot be said. Presumably in the infant or young child closure of the eyes is the most satisfactory single behavioral index of the onset of sleep. As noted above, this would ordinarily correspond in the pattern sequence to the peak status of the 4-5 per second drowsy waves and the correlative failure of the alpha waves. Some indication of depth of sleep may be obtained from regularity of breathing, the amount of movement, and the relative ease with which the child may be aroused (either by shaking him or speaking to him).

reached their peak, the 12-14 per second waves are recurrent every few seconds in well-defined bursts varying from one to three seconds in length and averaging usually from 20 to 50 μv in amplitude Occasionaly these waves may be superimposed upon short series of the slower irregular drowsy waves which still persist or they may show repeatedly against a prevailing low-voltage random background They may continue for as long as an hour Usually long before this, however, the activity has begun to decline, the intervals between bursts becoming progressively longer, the bursts shorter, and the amplitude of the waves less At about the time this decline begins, or, in some cases, even before it is noted, large "delta" waves (at about 1-3 per second) begin to appear in conjunction with the 12-14 per second bursts One then notes again during the ensuing period of minutes the process of the simultaneous decline of the one rhythmic activity and the gradual reinforcement of the other Finally, in what appears to be deep sleep, the 12-14 per second waves have either disappeared entirely or have become inconspicuous and the slow 1-3 per second delta waves stand out as the main component in the pattern. One may still note at this time repeated short irregular series of the 3½-6 per second drowsy waves which were at their peak much earlier in the sequence, these latter often being superimposed on the slower delta activity The delta waves may show all degrees of synchronism. Typically, however, they tend to be less regular than the other rhythmic waves which precede them Occasionally they may show periods as long as 2 or 3 seconds

During later infancy and early childhood the awake-sleep pattern sequence outlined above appears to remain basically unchanged Noticeable modifications do, however, occur in the scope of the two beginning stages of the sequence, namely (*a*) the initial alpha wave phase and (*b*) the succeeding stage marked by the appearance of the slow drowsy waves over the sensory-motor region. These modifications are in the direction of a strengthening of the alpha wave stage and an apparent decline in the dominance of the succeeding pre-sleep drowsy phase.

Some indication of the nature of these changes may be obtained by comparing Figure 3*a* and 3*b* with Figure 2*b* In comparison with the attenuated 5 per second beginning alpha wave sequences given by the 7 months old child (Figure 2*b*) the 28 months old child

(Figure 3a) and the 5 year old child (Figure 3b) show well-defined alpha rhythms at about 8½ and 9 per second respectively. These rhythms, while maximum in amplitude over the occipital area (leads *A*) also in each instance spread noticeably into the post-central region (leads *B*). On the other hand, the 4 per second drowsy waves shown by these two children appear to have declined noticeably in comparison with those of the younger child. Instead of the long well-defined sequences of these slow waves from the sensory-motor area during the pre-sleep drowsing period, only short attenuated series are observed. The remainder of the pattern sequence for each child following closure of the eyes and the onset of sleep is seen to be closely similar to the trend outlined above for the 7 months old infant. The sequence shown for the 5 year old child is somewhat atypical in that the bursts of the 12-14 per second waves are briefer and more irregular than usually observed. Child *A. R.* (Figure 3a) shows an effect often noted in other children but usually not so marked. Soon after the onset of sleep there was noted in this child a gradual increase in the amplitude of the entire pattern which after a few minutes became so great that the gains had to be reduced 50 per cent to prevent the undulator pens from continually swinging off scale. The amplitude of the large slow waves appearing at the end of this sequence reaches a maximum of about 500 μv.

In the infant or young child, the awake-asleep sequence usually proceeds systematically and the terminal deep sleep delta stage is ordinarily established within an hour. If the child has been kept awake for some time before the run begins and is very sleepy, it may require as little as 10 or 15 minutes to attain the slow delta stage and the intervening stages may be quite brief. During the further course of sleep, the pattern may fluctuate considerably, shifting back and forward from one stage of the sequence to another. The pattern may, for example "rise" recurrently from the slow delta stage to the phase marked by the repetitive 14 per second waves. Or, it may even skip this latter stage and shift abruptly to the earlier drowsy state following which the drowsy to 14 to delta portion of the sequence may be repeated. "Rises" in pattern or shifts toward the beginning end of the sequence are usually correlated with movement of the child, with coughing or with some other disturbance such as urination. The appearance of regular series of 3½-6 per second drowsy waves in particular often forecasts a period of fussing or moving or the onset of waking.

Thus far in describing the *e e g* during sleep, no mention has been made of the intermediate 7 to 8 per second sensory-motor area waves. As the writer has thus far observed them, these latter waves appear to have no set sequential relation to any of the other rhythms They appear erratically and may be seen during any phase of the sequence. In the 3 months old infant (Figure 2*a*) they failed to appear; in Figure 2*b* they are seen momentarily along with the slower drowsy waves just after the eyes close, in Figure 3*a* they are seen in well-defined form superimposed on the slow delta waves, and in Figure 3*b* they appear when the delta waves recede for a brief period. There appears to be little doubt that they do represent a separate type of activity differing from either the alpha waves or the slower drowsy waves In some children they have been observed during apparent waking states, appearing over the sensory-motor area while the occipital leads were simultaneously showing alpha waves at a noticeably and consistently different frequency In others they have been noted in apparent antagonism to and in alternation with the slower drowsy waves, both appearing over the sensory-motor area.

C. Discussion

Recent investigators of the changes occurring in the adult *e e g* during sleep are in general agreement on two main points, (*a*) the disappearance of the alpha waves at the onset of sleep or early in the sleep interval, and (*b*) the domination of the pattern in deep sleep by large slow (½-5 per second) waves (1), (2), (3), (4). The writer's observations are seen to be in qualitative agreement with these findings It is of interest, however, to compare further the findings on infants and young children with the more detailed analyses presented by Davis, Davis, Loomis, Harvey and Hobart (2) These writers have suggested a series of stages describing the pattern changes occurring in the *e.e g* during sleep. In the adult the pattern sequence begins in the awake condition with the alpha waves present A drowsing phase follows, marked first by the appearance of breaks in the alpha rhythm ("floating") and then by the appearance of delta waves as the alpha waves disappear completely Delta waves are defined simply as being "0 2 per second or more in length" A third stage is indicated by the appearance of 14 per second "spindles" *in recurrent short bursts*, along with the delta waves This stage is in turn supplanted by a fourth in which both delta and spindle

waves increase in voltage and the delta waves increase in length Finally in "deep sleep" the spindles have become inconspicuous, but the delta waves continue to increase in amplitude and in length This pattern sequence appears to be in close agreement with that described above for infants and young children One discrepancy, however, may be noted This discrepancy involves the progressive slowing of the "delta" waves which Davis, *et al.*, describe as occurring during the course of sleep The writer has not been able to observe any systematic slowing of the 3½-6 per second waves. Our observations would indicate that these waves are at a maximum over the sensory-motor area just as the eyes close. They become less dominant over a period of minutes preceding the appearance of the 12-14 per second waves, but persist after these waves begin to show, and are still present when the latter have been succeeded by very slow waves at 1-3 per second They are sometimes noted superimposed on the much larger slower waves, but usually appear in short somewhat irregular sequences mixed in with the latter waves. The fact that both frequencies appear in the newborn in random association and in such a way as to indicate no necessary sequential relation between them also suggests that they may represent different types of activity. It is for these reasons that the writer has tentatively suggested two frequency bands, one at 3½-6 per second ("drowsy" waves) and the other at about 1-3 per second ("delta" waves). More systematic observations will be required to validate this apparent discrepancy between the "delta" and "drowsy" waves.

Intermittent brief interruptions of the alpha waves akin to the "floats" described by Davis, Davis, Loomis, Harvey, and Hobart have been noted in infants and young children. In the absence of any possible verbal report by the child, however, we are unable to determine whether such a break is indicative of a momentary "dozing off" as it appears to be in the adult. We are forced to rely on the possibly less sensitive criterion of the appearance of the 3½-6 per second sensory-motor area waves as an indication of drowsing.

In addition to the basic finding that the *e.e.g.* of the infant or young child undergoes systematic alteration during the onset and course of sleep, several other observations appear to be of some significance relative to the process of development governing the *e.e.g.* Primarily, we may note that apparently all of the funda-

mental aspects of the growth process whereby the adult awake-asleep pattern sequence is established are crowded into a brief ontogenetic interval ending 5 or 6 months after birth These accomplishments include the emergence of the several sensory-motor area activities, presumably in utero, since they may be observed at birth (6), the assumption by these various rhythms of their proper places in the sleep sequence, which appears to take place during the first three or four months following birth, and finally the emergence and establishment of the alpha waves (7) When, at 5 or 6 months, the alpha waves are established, the infant pattern sequence is apparently comparable in scope and essentially similar in detail to the adult sequence Subsequent development is more gradual and less sweeping in character and appears to involve chiefly alteration in the alpha wave component of the sequence. As the latter waves increase gradually in frequency, in amplitude, and in length of rhythmic sequence, the initial awake alpha phase occupies a more dominant position in the sequence Correlatively, as we have seen, the 3½-6 per second "drowsy" waves may decline to some extent In contrast to the earlier rapid growth, however, these changes take place over a period of several years.

Summary

The *e e g.* undergoes systematic and predictable alteration in pattern during the onset and course of sleep. The scope of this alteration depends upon the age of the child. In the newborn comparatively little differentiation may be noted in the awake-asleep pattern sequence By the time the alpha waves are established at 5 or 6 months, however, the pattern sequence has become basically similar in scope and comparable in detail to the changes observed in the adult *e e.g* during sleep

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Conditions Only those books that are listed below in this section are eligible for such reviews All general elementary textbooks are eliminated Those books that are included, even though some of them might be poor, are probably the ones that make the most difference to psychology or deal with problems or techniques that are fundamental to psychology at the present time The list begins with January, 1936, and the books are listed approximately in the order of receipt. New 1938 books will be added as they come in At the end of 1938, all of the 1936 books will be removed from the list

A reviewer must possess the Ph D degree or its equal in training and experience. The Editor thinks of graduate students with affectionate regard, but he cannot accept reviews of this type from them.

A review must be written strictly at the professional level. It must not occupy less than two printed pages, nor more than twenty. It must avoid trivialities, such as chapter divisions, spelling of words, typographical errors, or any other matters that the reader is not looking for in that book. A review must not be a soap-box or pulpit from which the reviewer exhibits his own intellectual hobbies or private feelings. It is the book that is being reviewed, and the

book must occupy the stage. No competent review will use such make-believe weapons as *"but this is not psychology,"* or *"but this is biology."* The classifications of old-fashioned college catalogues are not of vital importance in these columns. A competent book deals with issues, or with techniques for the investigation of issues. A competent review identifies those issues, determines their importance, and evaluates the success or failure of the book in the accomplishment of its purpose. For a reviewer to point out that the purpose of a book is not his purpose, is in fact a statement by means of which the reviewer substitutes himself for the book. That type of vulgarity has no place on the stage of great books.

Procedure. If among the books below there is one about which you have thought, and concerning which you have formulated some ideas, you are invited to write a review of that book. No matter if the book has been reviewed several or a dozen times. It is important that your colleagues know your comprehension of the book and its significance. In this way professional opinion will prevail quickly, and uncritical theories, unimportant or badly conceived investigations, misinterpretations, insufficient evidence, or uninspired work of any kind will stand revealed.

(Authors of reviews will receive a check immediately the size of which will be within the limits named above. The Editor will gladly receive nominations for inclusion in this list.)

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LEWIN, K. Principles of Topological Psychology. New York: McGraw-Hill, 1936. Pp. 231.

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BECK, S J Introduction to the Rorschach Method *Res Monog, Amer Orthopsychiat Asso*, 1937, No 1.
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MURPHY, G, MURPHY, L B, & NEWCOMB, T M Experimental Social Psychology. New York Harper, 1937 Pp 1121
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TERMAN, L. M, & MERRILL, M. Measuring Intelligence Boston: Houghton Mifflin, 1937. Pp. 461
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THURSTONE, L L Primary Mental Abilities *Psychomet Monog*, 1938, No. 1 Pp 121
SPEARMAN, C. Psychology Down the Ages (2 vols.) New York: Macmillan, 1938 Pp 454 & 355
GESELL, A, & THOMPSON, H The Psychology of Early Growth New York, Macmillan, 1938 Pp 290
STEVENS, S. S, & DAVIS, H. Hearing Its Psychology and Physiology New York Wiley, 1938 Pp 489
STRONG, E. K Psychological Aspects of Business New York. McGraw-Hill, 1938. Pp 629.
BOAS, F. The Mind of Primitive Man (Rev ed) New York: Macmillan, 1938 Pp. 285.
SHERMAN, M Mental Conflicts and Personality New York Longmans, 1938 Pp 319
GUTHRIE, E R The Psychology of Human Conflict. New York: Harper, 1938. Pp 408
MURPHY, G, & LIKERT, R Public Opinion and the Individual New York Harper, 1938. Pp 316

KATZ, D., & SCHANCK, R. L Social Psychology New York Wiley, 1938 Pp 700.

ELLIS, W. D. A Source Book of Gestalt Psychology. New York Harcourt, Brace, 1938. Pp. 403

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SKINNER, B. F The *Behavior of Organisms: An Experimental Analysis* New York. Appleton-Century, 1936 Pp

SEASHORE, C. E. Psychology of Music New York McGraw-Hill, 1938. Pp. 408.

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CRITICAL REVIEWS OF RECENT BOOKS

(*Shaffer, Laurance F The Psychology of Adjustment. New York Houghton Mifflin, 1936. Pp 600.*)

REVIEWED BY GLADYS C SCHWESINGER

The aim of this book is to assist the reader to get a clearer and broader perspective on human nature in general and on individual differences in personality, to point out why differential behavior-patterns come into being, and how, if these differences are too far removed from acceptable norms, they can be guided into approved or at least tolerated forms of behavior. A grasp of the subject matter of this book will enable the reader to understand himself better in relation to other people, to understand the behavior of others in relation to himself, and to become objective in observing personality unfold itself wherever human beings interact. The need to attain objectivity in the area of human relationships, while it conceivably would include everybody who is living in a socialized environment, is specified particularly for those workers who must "deal with people" in their day-to-day activities, such as the teacher, the social worker, the personnel administrator, not to mention the doctor, the minister, the nurse, the lawyer, the parent, and others in the professional and non-professional service groups whose duty it is to guide, influence or control people, or to teach them how to live at peace with themselves and to adjust to one another.

The *Psychology of Adjustment* has been designed as a college textbook, to be used in courses following some general introductory course in psychology. It can well serve as text in courses on mental hygiene, on the psychology of personality, in the newer courses to come soon—we hope—on "human relations," and it will supplement in an effective way the textbooks usually reserved for courses in abnormal psychology, for it includes over two hundred pages of discussion on motivation and the mechanisms of adjustment to be noted in variable quantitative expression among both the normal and the abnormal The book is vitalized by an abundance of illustrative material, some of the cases cited having appeared in other published sources, but many of them being presented for the first time, and all of them, even when brief, showing indications of having been recorded by trained observers

Shaffer presents what can be considered the most complete array of concepts and hypotheses of the problems and processes of psychosocial adjustment yet assembled between the covers of one text. In his consideration of motivation, he is careful to avoid employing the assumptive psychoanalytic concepts, such as the Ego, the Id, the Unconscious, *et al.*, although in fairness to the stimulating contributions of psychoanalysis, he devotes a separate chapter to outlining the chief psychoanalytical theories. At the end of each chapter appears a well selected list of reference readings, which are implemented at the close of the book by a series of questions and exercises, arranged according to pertinent chapter discussions, to aid the student in applying his newer insights into human behavior. Thus the book serves its purpose as a teaching device more effectively, giving factual information on the one hand, and intellectual provocation and the opportunity to test out the theories by discussion of implications, on the other. The actual practical application to persons will be the true test of the efficacy of the teaching, as well as of the student's psychological capacity and skill.

The main thesis of the book is that the most effective way to arrive at the truth concerning human nature is to investigate it by the scientific method: to observe the data—which for human behavior is often synonymous with the "symptoms," or even of the complaint as recorded by the associates of the patient or subject," to classify the symptom-behavior traits and to relate them to conditions in which they are manifest, to generalize from the findings, and if the investigations and diagnosis have been accurate up to this point, to predict future behavior for known people under known conditions. If "cause" and "effect" continue to check for the individual in question, then skill in knowing people and understanding human motivation and its encounters with frustration, will have been established. What to do about the behavior of the maladjusted person, if anything, is reserved for the last section of the book.

Variations in approach to any study of human nature are also acceptable to science. There is the experimental approach, setting up controlled conditions, there is the measurement of characteristics or samples of conduct by appropriate test or other technique, and the intensive case study, etc., all of which yield results which can be used and interpreted by the trained and critical observer.

Diagnosing and adjusting human beings is a serious business, not to be undertaken lightly, not without the broad psychological understanding of the scientist plus the deft artistry needed by the practitioner It is to supply the former equipment, that this book has been written. For training in practice, the would-be consultant should adopt some connections akin to the apprenticeship, internship, assistantship under close supervision of a skillful and experienced counselor, and "learn by doing"

The fundamentals of human behavior in general, the basic issues in adjustment, have been derived on the whole from the control-experimental approach They include a study of nature-nurture influences in human development. instincts (with no penchant or prejudice for any special school of psychology), reflex behavior before and after birth; establishing conditioned reflexes; emotions (again no loyalties or biases strained), their physical bases and modifications and a consideration of other motivations such as drives, needs, habits, sentiments, cultural pressures, set up by physiology and society

But motives clash in their demands for satisfaction and set up problems for the adjusting organism to meet problems often admit of several solutions The devious ways in which personality discovers and accepts solutions are what make life colorful to the observer In this section on varieties of adjustive behavior, Shaffer has summed up all the defense mechanisms yet suggested. Professional insight into the different outlets which people have evolved when personal defect or feelings of inferiority are confronted with a demanding environment, has been derived largely from individual case studies Frustration produces tension, acute or chronic, which seeks release through compensations, rationalizations, etc., or fails to resolve itself, producing non-adjustive states of all degrees of severity, running from the simple worrier to the victim of a "complete nervous breakdown"—a term loosely employed by many physicians to indicate the crisis which follows a period of persistent non-adjustive tension

Material, gathered by the case method, and interpreted by the person having the facts in hand, is bound to yield a point of view more subjective than that accumulated by test or controlled experiment So if, occasionally, the author appears to be a bit dogmatic in his statements, it is readily forgiven him, particularly in this

section. But no consultant can read through these chapters without enjoying a greater feeling of security that his own next case will benefit by the greater insight which the reading has brought.

To discover something of the origins of differential personalities, why different people meet what seems to be the same challenging or equally baffling conditions in different ways, the author turns to that mass of data which has accumulated from tests. Differentiation and measurement of personality traits and an attempt to trace the origin of different adjustive tendencies are the two basic themes of Section III. That these chapters are less rich in source material than the preceding section and that the scientific contribution of much of what is given is undoubtedly narrow in its foundations, points not to a shortcoming in the author's treatment, but to a need for greater professional attack on this angle through controlled research approaches. Shaffer has made good use of those already available, the objective studies recorded throughout psychological literature. Data on organic factors and influences, variations ascribable to heredity, even the connection between the endocrine functioning and personality are still more speculative than real as evidence. Treatment of these topics is becomingly restrained.

But the prize for stress on empirical material goes to the last section on the techniques of mental hygiene. Here are reviewed the various practical methods for studying and treating the maladjusted individual. The case history outline is given in detail, followed by a rather full discussion of various approaches to psychotherapy, including the principles of positive mental hygiene. Equally important, is the author's square-faced recognition of the need to treat the environment as well as the individual. To bring this down to a specific concrete level, he outlines the applications for the relationships to be expected in the family, in education, in industry, and in social work, always of course appreciating the uniqueness of each individual.

If the problems of human adjustment are to be approached and solved by the scientific method, then there must be recourse to a funded "science of human relations," call it the psychology of adjustment, the psychology of personality, or what you will. In the preceding paragraphs, we have suggested that much of the funded knowledge on which Shaffer has drawn, does not meet even the relatively rigorous restrictions which psychology has set for itself

as a science. Of this, the author is just as much aware as is the reviewer But a discipline which has drawn from all the scientific sources available, and which has supplemented this learning with objective observations from a steady common sense obtained through controlled experience, is capable of producing principles which time and later wisdom will not lightly dislodge. They bring with them an illumination which can clear out much of the fumblingness that has characterized adjustive efforts in the past· Adjustment proceeds from the impulsions of a motive, which when thwarted, tries by trial-and-error reactions to reduce the accumulating tensions Psychotherapy can revise maldeveloped motives, can re-orient maldeveloped sensitivities which become articulate at the thwarting stage, or can assist most effectively at the trial-and-error adjustive attempts by offering insight in the place of random behavior.

It is the rare individual indeed who can guide himself out of his own well-grounded maladjustments, this is the *raison d'être* for the professional consultant. If the latter is successful in administering his diagnostic and advisory service he should not want for patients, for maladjustments, slight or serious, are in the order of living in a highly socialized and competitive world. People need and want help There should be centers and consultants where they can get it. But they do not always know what they need, or where they can get relief And while this book is primarily designed for the consultant, it is safe to predict that if it reaches far into the hands of the laity, it will also serve an excellent purpose in bringing home a recognition that adjustive psychological service exists.

At the present time, we are witnessing a drive for unified and broader national health consciousness and services, this after several centuries of experience with the practice of medicine. How soon can we expect a similar orientation for mental health and social adjustment for the normal range of human beings? Psychological consultations should not be exclusively the possession of the seriously disturbed.

We hear on every hand that the next great area for exploration and invention will be in the social sciences, especially in the field of human relationships Psychology has not yet yielded any too many techniques or instruments for service in this effort. A new discipline is being prospected and developed, and in the not too distant future may set up its own landmarks and shingles, pointing to service sta-

tions for suffering humans. In the meantime, gleanings from psychiatry, the psychology of personality, sociology, anthropology, and biology are being pieced together to serve as a springboard for the human relations expert There is to date probably no better single text aid than Professor Shaffer's book.

American Museum of Natural History
Central Park West at 79th Street
New York City

BOOKS RECENTLY RECEIVED

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1. [illegible] of Behavior in the Albino Rat—R. L. [illegible]
2. [illegible] in the [illegible]—M. F. [illegible]
3. The Limits of Learning Ability in [illegible]—A. M. [illegible]
4. [illegible] and Intelligence—A. M. Leahy
5. On Intelligence of Epileptic Children—[illegible] and [illegible]
6. A Study of the Play of Preschool Children by an Untrained Observer—[illegible]

VOLUME 18—January-December, [illegible]

1. Sex Differences in Variational Tendency—Q. McNemar and L. M. Terman
2. The Process of Learning to Dress among Nursery-School Children—C. D. Key, M. R. White, A. [illegible], F. Honzik, and D. Erwin
3. A Study of the Present Social Status of a Group of Adults Who, When They Were in the Elementary Schools, Were Classified as Mentally Deficient—Wilma Baller
4. The Influence of Specific Experience upon Mental Organization—Anne Anastasi
5 & 6. Studies in Aggressiveness—Lauretta Bender, Sylvan Keiser and Paul Schilder

VOLUME 19—January-December, 1937

1. Psychological Bases of Self-Mutilation—Christine [illegible]
 Masculine Temperament and Secondary Sex Characteristics: A Study of the Relationship between Psychological and Physical Measures of Masculinity—Howard [illegible]
2. A Psychological Study of [illegible] Mothers—Ruth D. [illegible]
 Behavior Problems in the Children of Psychotic and Criminal Parents—Lauretta Bender
3. Domination and Integration in the Social Behavior of Young Children in an Experimental Play Situation—H. [illegible] Anderson
4. The Sequential Patterning of Prone Progression in the Human Infant—Louise Bates Ames

VOLUME 20—January-December, [illegible]

1. The Relationship between Characteristics of Personality and Physique in Adolescents—[illegible]
2. Behavior Problems of Elementary School Children: A Descriptive and Comparative Study—[illegible]
 Graphic Representation of a Man by Four-Year-Old Children in Nine Prescribed Drawing Situations—Frances [illegible]
3. Differences between Two Groups of Adult Criminals—[illegible]
4. A Comparative Study by Means of the Rorschach Method of Personality Development in Twenty Pairs of Identical Twins—Evelyn Troup
 Individual Differences in the Facial Expressive Behavior of Preschool Children: A Study by the Time-Sampling Method—Carla Swan

VOLUME 21—January-December, [illegible]

1. An Experimental Analysis of "Level of Aspiration"—[illegible]

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